The development of speech processing skills in children with and without speech difficulties

Elizabeth Nathan

Department of Human Communication Science
University College London

Thesis submitted for the degree of Doctor of Philosophy
in Human Communication Science

July 2001

Abstract

Children with developmental speech disorder of no known aetiology constitute a heterogeneous group, both in their presenting difficulties, which can include additional language and speech perception difficulties, and in the developmental course of the disorder. This thesis examines this heterogeneity from a developmental and psycholinguistic perspective.

Using a longitudinal design, speech processing and language skills are explored over three years in a group of children with speech difficulties (n=47) and an age- and nonverbal IQ-matched longitudinal control group (n=47), mean age 4;06 - 6;07. Other measures were of developmental history, family history, psychosocial status and therapy input.

Key areas of investigation were: the proportion of children whose speech later resolves; uncovering the 'resolving' and 'persisting' profile; the role of input processing in speech development, in particular, the role of accent variability; and the occurrence of dissociable speech processing patterns on matched word/nonword repetition and on speech input tasks. Group characteristics were examined through an analysis of patterns of dissociation on tasks across the group and an examination of patterns of association on speech and language measures (in comparison to the control group) in order to establish the developmental relationships between different aspects of speech processing. Thus concurrent and longitudinal relationships were examined using descriptive statistics, prospective and retrospective subgroup analyses and multiple regression analyses.

A 'persisting' speech profile was identified as a pervasive speech processing and language difficulty and/or more severe speech output problems. A 'resolved' profile was confined to early, moderate, specific speech difficulties. Apart from nonword repetition, there was no evidence that speech outcome was related to different rates of speech or language development.

Using evidence from normal and atypical development, an interactive view of speech development is outlined. Despite the need to understand development as interactive, speech output performance is argued to be the main factor mediating and constraining change between the ages of 4-6 in children with speech difficulties.

An emerging discrepancy between word and nonword repetition, with nonword repetition not improving at similar rates to word repetition in some children with persisting speech difficulties, is cited as additional evidence that speech output, in particular, motor programming deficit, is the core characteristic of a persisting speech disorder.

Table of contents

Page

Page

Page

List of tables

List of Figures

Acknowledgements

Professor Bill Wells (University of Sheffield) is thanked for being a great supervisor, first, when I was an Msc student and now, during my PhD studies. He has had a huge influence on my thinking, his comments are astute and thought-provoking, and he has gently guided and developed my work. He is always generous with his time and with his ideas, and I appreciate this greatly.

Professor Joy Stackhouse (University of Sheffield) is thanked for her nurturing role, gentle guidance, enthusiasm, friendship, support and for her inspiring ideas. Joy has had a formative influence on my life and career, from when I first was taught by her as an Msc student in 1992 and particularly as her research fellow from 1995-1999 and this influence continues. She has enabled me to achieve things I would never have believed possible.

Thanks go to **Dr. Chris Donlan** (University College London) for taking on a supervisory role at a late stage in the completion of this thesis, for his insightful comments on some draft chapters and for his enthusiasm and support that saw me through the final stages of the write-up.

During my time as a research fellow, **Professor Maggie Snowling's** (University of York) input has been invaluable: directed, insightful and inspiring.

Many colleagues at the Department of Human Communication Science are thanked for their help: **Dr. Nata Goulandris**, for support and encouragement over many years. I thank **Dr. Maggie Vance** and **Rachel Rees** and the Developmental Research Team from whom I have learnt a lot. Their support during my write-up is greatly appreciated. **Dr. Jane Maxim** has supported my thesis write-up in very practical ways for which I am very grateful. **Sarah Alleemudder** has also been unfailingly helpful in practical matters. **Marcin Szczerbinski**, a fellow PhD student (now of the University of Sheffield), has been a great friend during our PhD careers at UCL. Our conversations during periods of statistical analysis and write-up have been invaluable in the development of this study.

Stevie Russell and her colleagues from the library at Human Communication Science are also thanked.

Thanks to **Dr. John Adams** (Department of Psychology, University of Durham) for help in the scoring of the Strengths and Difficulties Questionnaire (Goodman, 1997).

North Thames Regional Health Authority is acknowledged for funding the collection of data analysed in this thesis through a Research and Development Grant (1995-1999) on which I was research fellow.

Thanks to all the **speech and language therapists** from **Camden and Islington Community Health Care Services NHS Trust, Barnet Health Care NHS Trust, Enfield Community Care NHS Trust, The Nuffield Hearing and Speech Centre** who supported this work by referring children to the study and completing questionnaires.

Many **headteachers, SENCOs** and **teachers** from over 50 schools co-operated with the study and welcomed me to their schools. This is very much appreciated.

Sincere thanks are offered to the **children** and their **families** who participated in the study.

I would like to thank my **parents** for their help and assistance over the years.

Thanks to **Joanne** for some emergency last-minute proof-reading.

Finally, I thank **Jeremy** for all his support.

In memory of my grandmother

Else Nathan

who completed her PhD in 1929

at the University of Albertus, Königsberg, Prussia.

The title of her doctorate was *Inflation and Public Opinion.*

Chapter 1
Speech disorder and heterogeneity

1.1. Overview of speech disorder

Childhood speech disorders are one of the most frequent types of communication problem that speech and language therapists are likely to encounter (Enderby & Philipp, 1986). Whilst some speech disorders are attributable to hearing loss, structural or physiological abnormalities like cleft palate and cerebral palsy, and cognitive impairments, the majority of children with speech difficulties have no recognisable aetiology.

Children with speech difficulties are likely to have a variety of co-existing problems, including additional language problems (e.g. St. Louis, Ruscello & Lundeen, 1992; Shriberg, Tomblin & McSweeny, 1999) and are also more at risk than the general population for problems with phonological awareness and the development of literacy skills (Bird, Bishop & Freeman, 1995; Larrivee & Catts, 1999; Lewis, Freebairn & Taylor, 2000b). Those whose intelligibility is affected will have problems making themselves understood which will influence their ability to communicate effectively. Focus is often placed on the educational sequelae of early speech problems and the long-term consequences for people who are less intelligible and articulate than the general population (Hodson, 1994). It is also important to emphasise the wider social consequences of a speech difficulty. One study has reported that children with speech difficulties are two-to-three times more likely to have some type of psychosocial disorder (e.g. an attention deficit disorder or emotional disorder) than the general population (Cantwell & Baker, 1987) and links have been made between speech and language problems and psychosocial problems such as low self-esteem (Nash, Stengelhofen, Toombs et al., 2001). Whilst very young children with speech difficulties are often accepted by their peers, older children with persisting speech difficulties may experience some negative responses from those with whom they interact. Additionally, a phonological and/or phonetic difficulty will necessarily affect the extent to which a child can communicate using the accent system of his/her own accent community. Indeed, the degree of membership of a social network is seen as related to the extent of use of certain sociolinguistic variables (Chambers & Trudgill, 1980), with younger children particularly adept at accommodating to new accents and dialects (Payne, 1980; Kerswill & Williams, 2000). Hence, difficulty with speech development could hamper social relationships within a social network, and the ability to accommodate to the accent of new social groups.

Prevalence estimates for the disorder vary quite widely. A study conducted by Kirkpatrick and Ward (1984) of prevalence of speech disorder in Australia gives a figure of 4.6%. Shriberg and Kwiatowski (1994) quote an estimate of 2-3% of developmental phonological disorders in 3-11 year-olds in a series of studies conducted in the USA. In a later study (Shriberg, Tomblin & McSweeney, 1999), the figure is revised to 3.8%. However, the reported range of prevalence is wide, with some studies finding up to 10-15% of the normal school population may have speech difficulties (Ingram, 1972 as cited in Enderby & Philipp, 1986; Elliot, 1978, as cited in Enderby & Philipp, 1986). A systematic review of the literature reports an overall range of 2.3-24.6% (Law, Boyle, Harris et al., 2000).

Diverse estimates of prevalence rates reflect the diverse way in which the disorder is defined, assessed and identified, and even the label that is used. This problem of definition and classification is commonly recognised (Shriberg et al., 1999; Dodd, 1995; Stackhouse & Wells, 1997). Terms that have been used to describe speech difficulties are: dyslalia, developmental verbal dyspraxia, articulation disorder, speech disorder, phonological disorder, phonological difficulty, phonological delay, speech impairment, phonological impairment, phonetic disorder and speech processing difficulty. Each label is associated with certain theoretical assumptions that draw on linguistic, medical and psycholinguistic terminology. This, and the next, chapter will explore the evidence associated with some of these levels of explanation. Discussion will focus on how the heterogeneity of performance is seen to defy a single causal factor and how current theories of speech disorder address this issue through sub-classification systems or through the description of unitary, independently functioning speech processing systems.

1.2. Speech disorder: a linguistic perspective

In the 1970s and 1980s, through the publication of texts such as Ingram's *Phonological disability in children* (1976) and Grunwell's *Clinical Phonology* (1982), the study of phonology revolutionised the assessment and treatment of speech disorder. Speech development was seen as a process of learning a contrastive system of speech sounds (Grunwell, 1987) rather than simply movements of the articulators. The term 'phonological disorder' was coined to describe a speech difficulty that resulted from a breakdown at a cognitive level of linguistic knowledge compared to a 'phonetic disorder', which is more peripheral in nature. Emphasis was placed on identifying patterns in the speech data of a particular child and comparing these patterns with those identified in normal development. According to Grunwell (1987), a child with a phonological disorder might exhibit the following: persisting normal processes, chronological mismatch (i.e. co-occurrence of early with age-appropriate phonological processes), unusual processes (though Grunwell emphasises that it is likely to be difficult to classify normal versus abnormal processes), variable use of processes (variability can occur within the same word or across words), and systematic sound preference. Stoel-Gammon (1991) adds a further characteristic: limited word and syllable shapes. These characteristics are based on assumptions about the timing of normal phonological development and thus an individual child's divergence from this normal development. While our knowledge of normal phonological development indicates that children pass through a relatively fixed and sequential order of acquisition, it has been observed that small group studies often show a large degree of individual variation in early language development (Stoel-Gammon, 1991). Larger studies of normal development actually present generalisations that mask the inherent variability of the data. Making precise judgements about what constitutes atypical performance is thus problematic.

The distinction between phonetic and phonological disorders has also been called into question by the use of instrumental techniques such as electropalatography (EPG) and instrumental acoustic analysis of speech. Weismer (1984), in a review of temporal and spectral studies, describes how children who appear to a listener not to be making a particular phonological contrast, e.g. voicing, may indeed be signalling a distinction which is not perceptually salient. In the voicing example, an acoustic analysis of voice onset time (V.O.T.) might reveal that the child is making a phonological contrast that is measurable through burst amplitude or a difference in fundamental frequency immediately following the release of the sound. The implication here is that the child does not have a phonological deficit as such but is failing to make a sufficient contrast for a naïve listener to hear, possibly due to a constraint at a phonetic level, i.e. the difficulty actually arises at a motor speech level.

A further difficulty with the phonological approach is what Kent terms "*a clinical means and ends rolled into one*" (p.13, Kent, 1996). Describing a child's phonological simplification processes becomes a label in itself (e.g. "this child fronts") and, by extension, an explanation of the disorder ("fronting") as well as an indicator of how to proceed with intervention ("work on the fronting problem"). However, this approach is not explanatory and does not directly address how a particular speech problem might develop. It has been suggested that identifying typical vs. atypical phonological processes could give an indication of prognosis (i.e. typical processes are delays in development and are less a cause for concern than atypical or disordered development). However, there is little evidence that such processes explain or predict the course of the disorder, not just at an individual level, but also at a group/population level. The strength of the approach lies in offering a framework within which to make a detailed analysis of the surface speech errors of an individual child. One can identify patterns that are occurring across that child's speech that can be related and compared to the phonological patterns that have been identified in normal development.

1.3. Speech disorder and motor programming deficits

Before the linguistics revolution's influence on the study of speech disorders, there was an assumption that a child's difficulties were at an articulatory or motor co-ordination level (Lambert & Waters, 1995). Indeed many children with speech difficulties can have motor deficits that are associated with or causally related to the speech disorder. Children with a label of developmental verbal dyspraxia are considered to have, amongst other deficits, a problem with co-ordinating the fine motor movements necessary for speech (Ripley, Daines & Barrett, 1997).

While the term dyspraxia remains controversial (Crary, 1993; Shriberg, Aram & Kwiatkowski, 1997), motor difficulties have been noted in children with speech difficulties (not necessarily limited to those with a dyspraxic label). Others have also noted that some young children with speech difficulties do have poorer speech motor control as measured by diadochochinetic rates (Henry, 1990) and by mean articulation rates in spontaneous connected speech (Cohen & Waters, 1999). Pre-school children with speech disorders have also been found to use less controlled gestures on lingual and labial stop consonants, e.g. they were less able to manoeuvre jaw and tongue body separately (Edwards, Fourakis, Beckman et al., 1999). Ozanne (1995), in a study of 100 children with specific speech and/or language impairment aged 3;0 – 5;06, found quite a high incidence of motor programming difficulties in this group. Although it was not reported how many children exhibited no motor programming difficulties, a continuum of motor programming difficulties was reported.

The implication of this study is that some motor programming behaviours are exhibited in children attending speech and language therapy, with a range of severity, who have not been diagnosed with developmental verbal dyspraxia. This argument is also supported by McCabe, Rosenthal & McLeod (1998) who conducted a retrospective analysis of 50 cases of children with articulation/phonology problems, aged 2-8 years, who displayed behaviours commonly associated with developmental verbal dyspraxia. However, Bradford and Dodd (1996) argue that motor programming/planning deficits are not found in all children with speech difficulties. They found that it was children who made inconsistent errors or who were defined as having developmental verbal dyspraxia that performed more poorly on some oro-motor tasks.

Thus some evidence exists that the motor system is implicated in childhood speech disorder and that it is necessary to think beyond the purely cognitive framework that is suggested by a phonological approach.

1.4. The development of speech perception

Before reviewing the literature on speech input in the context of speech disorder, a brief review of the development of speech perception is given. The continued development of speech perception skills in childhood will be a particular emphasis.

There is accumulating research evidence from the last thirty years that demonstrates the sophistication of infants' speech perception skills. Infants are able to discriminate between many phonetic contrasts used in different languages. These discrimination skills are in place at infancy (Eimas, Siqueland, Jusczyk & Vigorito, 1971) and within the first year of life these perceptual capacities have become attuned to the native language. Indeed, between 7 and 10 months, there is a decline in infants' abilities to detect some foreign contrasts (Werker & Tees, 1984; Best, 1994), suggesting the beginnings of the development of language-specific phonetic recognition (Juszyck, 1992; Kent & Miolo, 1995). There is even some neurophysiological evidence for the development of language-specific memory traces in the brain before the age of 12 months (Cheour, Ceponiene, Lehtokoski, Luuk et al., 1998).

Whilst this body of work has increased our insight into the very early development of speech perception, it is also clear that these skills continue to develop through middle childhood or later (Locke, 1993). Infants may have an acoustic capacity that is aligned to the demands of speech, but further development is required for a language-specific phonetic and phonological system. Evidence from second language learning, that children are better than adults at learning foreign languages with a native-like accent, suggests that there is a degree of plasticity within the speech system throughout middle childhood (Walley & Flege, 1999). Exploration of the continued development of speech perception skills and the phonological system has been a relatively neglected area in the literature until recently (Walley, 1993).

Locke (1993) describes three processes that occur in the development of speech perception: maintenance, learning and loss, i.e. through exposure to one's native language, a child maintains some perceptual biases but alters others and loses others from the system. The child's speech perception system undergoes refinement as relevant acoustic properties are integrated and irrelevant properties minimised. Burnham (1986) describes two distinct periods when some speech perception abilities are lost. After a period in infancy, a second period of loss occurs between the ages of four and eight. In this period, the loss of the ability to perceive phonetic contrasts that are phonemically irrelevant to the child's language occurs and is related to the increasing experience the child has with his/her own language.

Another theory proposed by Nittrouer and colleagues describes a 'developmental weighting shift' which occurs gradually. This theory emerged from consideration of the problem of co-articulation. Co-articulation makes it difficult to recover and isolate the underlying phonetic segments in a syllable or across syllables. Nittrouer, Studdert-Kennedy & McGowan (1989) found that younger children performed less well than older children and adults on differentiating between the two fricatives /s/ and /ʃ/, i.e. at a phonemic level. The younger children also showed greater effects of co-articulation of these fricatives with their accompanying vowels. This production task was taken as evidence that younger children tend to organise their articulatory gestures at the level of the syllable, rather than the phoneme. Perceptual experiments have backed up this finding (Nittrouer & Studdert-Kennedy, 1987; Nittrouer, 1992): earlier on, their weightings are different from adults', with more emphasis on dynamic cues, that signal syllabic rather than phonetic segments. It is acknowledged that children are poorer at auditory processing tasks as well (e.g. Elliott, Hammer & Scholl, 1989; Sussman, 1993). But there is not sufficient evidence to show that these differences in auditory sensitivity can account for the age-related differences found in these labelling/categorisation tasks (Nittrouer & Crowther, 1998).

This process of a weighting shift is said to continue up to the age of 7 years and represents a transition from larger units (whether they be words or utterances) to smaller units (phonemes) (Fowler, 1991; Walley, 1993). As well as contextual effects (e.g. co-articulation), children's speech errors have been cited as evidence for the use of larger units early on. Children are often able to use a phonetic form accurately in one word, but not in another, suggesting that they do not generalise the phonetic form across words but instead store a larger, unanalysed form (Studdert-Kennedy, 1987). Additionally, children may produce the same word differently on different occasions. The different attempts might show similarities in the types of gestures used (e.g. lip closure) but the ordering and inclusion of gestures may vary, suggesting that phonetic segments have not been sequentially stored (Studdert-Kennedy, 1987). Other experimental evidence has shown that there is a developmental change in children's categorical perception of consonants up to the age of 6 (Burnham, Earnshaw & Clark, 1991); still further refinement up to the age of 12 years has recently been demonstrated by Hazan and Barrett (2000). Also, Elliott, Hammer & Evan (1987) used a gating paradigm to show that young children needed to be exposed to a larger part of a word compared to teenagers in order to identify it correctly. This was taken as evidence that they required more of a word's constituents to respond. Because their perceptions of the words were more global, they found it harder to respond to single phonemes.

This shift from larger to smaller units entails the reorganisation of the speech perception system, resulting in the development of an adult-like phonological system. This shift is driven by vocabulary development. As the size and diversity of children's vocabularies grow, a reorganisation must take place so lexical items can be stored and retrieved accurately. As Locke (1993) puts it:

" *We should expect that phonemes fall out of words, that is, they are made possible by the child's knowledge of words*" (p.95).

There is now consensus that, as a result of this shift, the unit of the phoneme emerges rather than the previously held belief that phonemic segments were the unit of organisation in the infants' system. As well as this impetus from lexical development, Nittrouer and Crowther (1998) suggest that the development of speech production skills could also play a part. Children must learn to extract information from the speech signal that will enable them to create adequate articulatory instructions. With an increasing vocabulary, there will be a greater need for speech output to become more accurate, and so the information that is extracted from the input must be more detailed.

As Walley and Flege (1999) observe, beyond infancy, perceptual ability is increasingly influenced or "*contaminated*" (p.308) by higher level cognitive factors, including memory and language skills. There is some evidence to show how different cognitive factors and different levels of linguistic processing will interact with perceptual skills. Ganong (1980) reported that lexical representations can affect one's perception of speech. In what was subsequently termed the 'Ganong effect', he found that a phonemically ambiguous segment in a spoken string was likely to be perceived as being part of a known word, e.g. the same phonemically ambiguous segment is interpreted as /d/ in the context of –ash, but as /t/ in the context of –ask.

The development of speech perception skills thus necessarily becomes bound up with the development of word recognition skills, where consideration of top-down lexical influences is as important as the study of bottom-up phonetic information (Vihman, 1996).

1.5. Speech disorder and speech input difficulties

1.5.1. The relationship between speech output and speech input skills

It is the case that children with profound hearing loss are likely to develop a poor phonological system, and the logic that an auditory component is influential in language development has led to research looking at the role of mild and fluctuating hearing loss or otitis media with effusion in speech disorder (e.g. Mody, Schwartz, Gravel & Ruben, 1999; Shriberg, Flipsen, Thielke et al., 2000; Shriberg, Friel-Patti, Flipsen & Brown, 2000). Findings in this area are complex: children with speech difficulties do not always have a history of hearing problems. Conversely, some otherwise normally developing children do have bouts of otitis media (Dodd, 1995) but have no subsequent speech difficulties.

Whilst the evidence for links of this kind are complex, subtle auditory processing difficulties not necessarily associated with otitis media have been proposed as an explanation of the disorder. An auditory explanation for speech difficulties would propose that children with speech problems have impaired perceptual difficulties and that these difficulties exert a causal influence on speech development (Bird & Bishop, 1992). Such causal hypotheses have been put forward as explanations of specific language impairment (Tallal, 2000) although they remain an area of controversy (Bishop, Carlyon, Deeks & Bishop, 1999). While there has been no firm evidence that auditory skills play a causal role in speech disorder, there is evidence to show that some children with speech difficulties can have auditory perceptual difficulties.

Evidence for a one-to-one relationship between children's speech production errors and their speech perception is equivocal. However, associations between input and output skills have been found. A study by Marquardt and Saxman (1972) found significant correlations between measures of speech output and the Wepman Auditory Discrimination Test in a group of 30 children identified with significant speech difficulties, as well as some who had language deficits. Raaymakers and Crul (1988) found a specific relationship between perception and production of r/w contrasts and

Groenen, Maassen, Crul & Thoonen (1996) noted a relationship between perception and production skills in a group of children with dyspraxia. The latter study found a significant correlation between auditory processing skill and the frequency of place of articulation substitutions in these children's production. However, there is little firm evidence of a substantial or linear relationship. One reason for this could be methodological: the difficulty in measuring the relationship between perception and production (Locke, 1980).

Bird and Bishop (1992) addressed this by individually designing sets of words for their auditory discrimination tasks for each of 14 participants aged five-and-a-half by including phonemes that the child either omitted or produced incorrectly. However, even with this method, they were unable to conclude a strong relationship between production and discrimination. The children could discriminate some sounds they could not produce, ruling out a one-to-one relationship. Overall severity of the speech impairment did correlate with real word auditory discrimination. However, it did not correlate significantly with nonword auditory discrimination. The authors make the important point that performance is influenced by task design. It is also possible that the differing relationship of word and nonword discrimination with speech output reflects the role of stored representations and top-down influences in speech development which may come into play with a real word, but not a nonword task.

1.5.2. Speech input deficits in children with speech difficulties

While the relationship between perception and production is debated, it is the case that a growing number of studies have found that a proportion of children with speech difficulties do show auditory processing deficits. Bird and Bishop (1992), in the same study described above, identified deficits in auditory discrimination of words and nonwords and phoneme discrimination tasks in their group of 14 children with speech difficulties, although deficits were not apparent for all the children. Broen, Strange, Doyle & Heller (1983) found differences between a group of 3-year-old children with delayed speech and a group of 3-year-old children with normally developing speech on 3 approximant consonants. Although the normally developing group had mastered these contrasts, some of the disordered group had not. However, performance was variable within the group and whilst some children's production errors were related to their perceptual errors, for other children, there was no such direct relationship. Rvachew and Jamieson (1989) also found group differences between older children with and without speech difficulties, this time, on the fricative contrasts of /s/ /ʃ/ and /s/ /θ/. Whilst for the first contrast, only a subset of the speech disordered group performed poorly, for the latter contrast, the majority had difficulty identifying this correctly. Watson (1997) (cited in Watson and Hewlett, 1998) found children with speech difficulties appear to have different perceptual strategies to controls. In this study, Watson presented children with words with word initial fricatives that had been spliced into 9 steps. They were required to identify the fricatives presented in minimal pairs. They were less accurate at this than the control group.

Perceptual deficits have also been identified in children labelled dyspraxic. Bridgeman and Snowling (1988) found that children diagnosed with developmental verbal dyspraxia were age-appropriate in discriminating words and nonwords differing by a single feature, i.e. /s/ /t/ and in discriminating words with the cluster sequence /st/ /ts/ but did have difficulty in discriminating nonwords with this cluster sequence. Groenen, Maassen, Crul & Thoonen (1996) also identified a selective deficit. They tested 8-year-old Dutch children with developmental apraxia on an identification and discrimination task using a seven step [b-d] continuum. The identification task was hypothesised to test phonetic processing because the child must classify each stimulus (from somewhere along the continuum) using a phonemic judgement of which endpoint the stimulus most closely resembled; the discrimination task, although contrasting points along the same continuum, was likely to be based on auditory processing ability as well as phonetic processing. The children were poorer than controls at discriminating monosyllabic words. However, they performed equivalently to controls on the identification task using the same continua, which, they suggest, shows that phonetic processing ability is intact while auditory processing is impaired in this group.

These studies suggest that some children with speech difficulties may have associated speech perception problems. However, because not all children with speech difficulties have these types of deficits, a single causal link cannot be concluded from these studies. In any case, causality is hard to determine using a cross-sectional methodology as is employed in the studies reviewed. Nonetheless, even if one hypothesised that early auditory perceptual development was crucial (as Bishop (1997) suggests could be a possibility), it would be hard to verify this even with a longitudinal study. One would need to recruit participants with speech disorder as infants, well before any speech disorder was apparent but when speech perceptual skills are already developing.

An alternative to an auditory processing deficit would be a deficit at the level of phonemic segmentation, as proposed by Bird and Bishop (1992). In addition to auditory discrimination tasks, they looked at phoneme matching performance. For the auditory discrimination tasks, the child was required to make same/different judgements of nonwords and to make judgements about the accuracy with which words were said. Both these tasks were individually designed using each child's phonological errors. For the phoneme matching task, the child had to categorise sounds or words, and to perform rhyming tasks. Whilst only a subset of the speech disordered group had auditory difficulties, there was more widespread difficulty with the phoneme matching tasks. It is argued that children with speech disorders have a more central difficulty with the accurate analysis and segmentation of words rather than perceptual difficulties, i.e. a problem of categorisation rather than discrimination. Their deficit lies with the ability to perceive phoneme constancy and is reflected in reduced awareness of the internal structure of phonological strings. One difficulty with this interpretation is that one of their measures of auditory discrimination (based on a procedure recommended by Locke, 1980) was the ability to recognise correct pronunciations. This task seems more related to a representational level (i.e. the ability to judge whether a stimulus matches an internal phonological representation) than to a lower level auditory discrimination skill. Additionally, tasks of phonological awareness have a greater cognitive load, and more widespread difficulty on these tasks could reflect task demands and may also be interpreted as the consequences of earlier (or concurrent) auditory discrimination deficits, as acknowledged by Bishop (1997).

In a slightly different approach, Edwards, Fourakis, Beckman et al. (1999) claim to show that children with speech difficulties do not have fully specified cognitive representations of the redundant perceptual cues available in the speech signal. They found that on two tasks, a gating task and a noise-centre vowel identification task (that required the children to identify words which had varying degrees of acoustic information removed), a subset of a small group of 4-year-old children with speech disorders had difficulties compared to controls. Whilst these tasks may indicate representational deficits, no tasks are presented in this study to rule in or rule out other levels of processing deficit. However, the notion that children with speech difficulties may have poorly specified, fuzzy or inaccurate phonological representations is becoming an increasingly popular view (Stackhouse, 2000; Rees, 2001; Waters, 2001). It reflects parallel work in the area of literacy research which proposes that representational difficulties may be fundamental and causative in the development of phonological awareness and literacy skills (Snowling, 2000; Elbro, Borstrom, & Peterson, 1998).

The studies reviewed consistently find a subgroup of children who are experiencing input processing difficulties. This result holds over studies that use a variety of tasks to test this skill. A variety of hypotheses are proposed about what the nature of the input processing deficit might be for these children and some studies explore these hypotheses by contrasting different tasks in an attempt to examine loci of difficulty (e.g. Groenen et al., 1996; Bird & Bishop, 1992).

1.5.3. Measuring speech input skills in children with speech difficulties

In evaluating the evidence for input processing deficits in children with speech difficulties, it is important to consider issues surrounding the ways in which these skills have been measured. A range of experimental tasks has been used in the studies reviewed in this chapter. Whilst some are used or have been adapted for clinical use, e.g. the same-different task used by Bridgeman and Snowling (1988), many are impractical to use clinically and remain as experimental tools. Speech Pattern Audiometry, developed by Hazan and colleagues (Hazan, Wilson, Howells et al., 1995) is promoted as a potential clinical tool, but such techniques are not in widespread clinical use.

There are several standardised measures of speech input processing in current use. Two well-known American tests are the Goldman-Fristoe-Woodcock Test of Auditory Discrimination (1975) and the Wepman Auditory Discrimination Test (1973). The Auditory Discrimination and Attention Test (MorganBarry, 1988) has been standardised on a UK sample. Such measures have been criticised, however. In order to understand the relationship between speech input and speech output, Locke (1980) argues that a perceptual task should not be pre-packaged but must be designed to take account of each child's own output errors. Winitz (1984) also contrasts these kinds of standardised general discrimination tasks with tasks that tap specific aspects of processing. Information from general tasks will relate to general auditory functioning, whilst specific tasks assess directly those distinctions that might relate to misarticulations. He argues that general tests may mask perceptual difficulties as they are not sufficiently specified, giving a false impression of a child's level of difficulty.

Several paradigms for assessing speech input processing are in use. However, criticism has been made of these. For example, AX or same/different tasks (where a child must discriminate between two adult forms) test discriminability (Locke, 1980), but if a response is incorrect it is unclear what criterion of sameness and difference a child was applying to the task. In order to assess a child's ability to discriminate between two adult forms, Locke proposes the use of an ABX procedure. The child must decide whether stimulus X matches stimuli A or B. The child therefore does not have to detect sameness or difference in the same way as an AX task, but must discriminate between items, knowing that two of the stimuli are supposed to be comparable. The problem with such a task is that the child must hold three stimuli in memory in order to answer accurately and the conceptual demands of the task could be considered to be even greater than the understanding of the terms 'same' and 'different' in the AX task.

Importantly, Locke promotes a 'speech production-perception task'. This type of task is aimed at assessing a child's ability to discriminate the adult surface form from the child's own internal representation of it. This assesses a child's knowledge about the phonological structure of his/her language by tapping stored representations.

Locke's critique of these tasks has been very influential and his promotion of both an ABX procedure and the 'speech production-perception task' have been taken up by other researchers (Stackhouse & Wells, 1997; Vance, 1996; Bird & Bishop, 1992). As reviewed elsewhere, Bird and Bishop (1992) conducted a group study incorporating these two paradigms as well as designing items for each child according to their speech output errors, as suggested by Locke.

Other factors also need to be considered in task design. The phonetic context in which the speech error appears should be considered, and, in interpreting results, it must be borne in mind that a child may perform differently depending on the linguistic unit being tested, e.g. words, syllables or sentences (Winitz, 1984). Winitz argues that even if a child appears to make adequate perceptual distinctions, the child may not be employing this knowledge in functional communication. Additionally, Bird and Bishop (1992) allude to the methodological issue of task sensitivity in discussion of their 'Auditory discrimination of real words' (with pictures) where overall performance was quite high. It is acknowledged that some of these difficulties in developing an adequate experimental paradigm for testing input skills have hampered our understanding of the relationship between speech input and output skills (Vihman, 1996).

1.6. Heterogeneity

1.6.1. Heterogeneity and subgrouping

The heterogeneity revealed by the studies that look at the phonology, motor skills and input processing skills of children with speech difficulties reflect a more general finding of heterogeneity in language disorders. There have been various attempts to address this question of heterogeneity. These include examining individual children in a case-by-case approach where generalisations about groups and populations are deliberately avoided. For example, Stackhouse and Wells' (1997) psycholinguistic framework does not assume that a child with speech difficulties belongs to a particular population or has a particular label but contrasts one child's speech processing performance with the normally developing population. This approach is reviewed in the next chapter. An alternative way of accounting for heterogeneity is to search for independent subgroups within the population that are homogeneous in nature.

Subgrouping has been a common strategy for exploring the heterogeneity in specific language impairment (SLI), resulting in a variety of classifications (e.g. Rapin & Allen (1987)). Conti-Ramsden, Crutchley & Botting (1997) review three ways that SLI can be subgrouped: clinically, psychometrically and linguistically, whilst concluding that a useful typology would have to combine features of all three. A quest for finding homogeneous subgroups is therefore practically and theoretically motivated as it may help to target therapy effectively and predict prognosis as well as increase our understanding of the nature of speech and language difficulties.

Two studies have attempted to subgroup samples of children with speech difficulties by the multivariate statistical technique of cluster analysis which searches for homogeneous clusters from multivariate measures, i.e. using a psychometric procedure to classify rather than a procedure that is primarily clinically driven. Arndt, Shelton, Johnson et al. (1977) used cluster analysis to identify homogeneous subgroups of a sample of 98 children aged 8-9 years with s/r articulatory difficulties. They took a wide range of measures including tests of language, auditory processing, school achievement (including literacy measures) and measures of oral structure. The clusters obtained did not differ from each other in terms of their articulatory status. A more recent study by Powell, Elbert & Dinnsen (1999) also employed this technique with a group of 21 children with articulation problems who were followed up at the age of 9;02. Whilst the technique of cluster analysis was able to identify homogeneous subgroups, it is not clear how the analysis increases our understanding of speech difficulties nor whether these subgroups are useful clinically.

Another approach to subgrouping, based on aetiology, has been proposed by Shriberg and colleagues (Shriberg, Austin, Lewis et al., 1997; Shriberg, 1997). He has devised a speech disorders classification system (SDCS) that organises subgroups according to both descriptive and aetiologic considerations. The aetiological classification consists of four putative subtypes of children aged 8 or younger with speech delay: 1) Speech delay: unknown origin, possibly genetic (60% prevalence) 2) Speech delay: otitis media with effusion (30% prevalence); 3) Speech delay: developmental apraxia of speech (3% prevalence); 4) Speech delay: psychosocial involvement (7% prevalence). Estimate prevalences are based on an analysis of clinical samples collected by this research group over a number of years. Each subtype is said to be associated with a biolinguistic or sociolinguistic distinction and the subgrouping aims to form the basis of a theoretical account of speech disorder where each subtype has different characteristics in terms of error patterns and its course of development. The main criticisms of this classification are that it may be difficult clinically to classify children in this way, many children may fall into two or more categories and, as yet, it is not clear what the patterns of performance are for each subgroup. Moreover, the largest category, 'unknown origin, possibly genetic' is vague as to aetiology.

Dodd (Dodd, 1995; Bradford & Dodd, 1994, 1996) has also been a principal exponent of subgrouping, based on linguistic criteria. Children are subgrouped according to the consistency of their surface speech errors. Following an initial classification of how consistent a child's speech production is over several occasions and whether errors are developmental or disordered, predictions are made relating to other skills, e.g. consistency of speech errors is related to other factors like phonological awareness difficulties. Thus, classification by surface speech error is said to reveal independent, underlying deficits: subgrouping is motivated theoretically by a psycholinguistic perspective, seeking to link surface speech performances with underlying speech processing mechanisms. The tasks used to identify underlying deficits related to consistency are wide-ranging: comparison of speech output tasks, motor skills, phonological awareness. However, it is unclear how speech input processing skill, a fundamental aspect of the speech processing mechanism, is related to her classification. Also, language skills are a co-occurring feature of speech disorders that need to be accounted for in a comprehensive account of speech disorder and its role outlined within the subgroup paradigm.

A general difficulty with subgrouping in this way is that a cut-off point has to be decided in order to place subjects in one category as opposed to another. These cut-off points are necessarily arbitrary since most variables will fall on a continuum rather than being present or absent. For example, defining at what point a child's speech is categorised as consistent or inconsistent (in the case of Dodd's subgroups) is subjective. Even if based on deviation between subgroups that is calculated statistically, such distinctions may not create clinically distinct subgroups, as evidenced by the studies using cluster analysis technique (Arndt et al., 1977; Powell et al., 1999). Further, there is the issue of stability of subgroup membership. One might expect less than perfect reliability in a classification system over time (Conti-Ramsden & Botting, 1999) as well as changes due to resolving problems or changing profiles over the course of development.

1.6.2. Heterogeneity related to additional language difficulties

The co-existence of speech and language disorders is a well-researched topic with many studies reporting language delay in children identified with speech difficulties (Paul & Shriberg, 1982; Lewis, Ekelman & Aram, 1989; St. Louis, Ruscello & Lundeen, 1992; Shriberg, Tomblin & McSweeny, 1999; Lewis, Freebairn & Taylor, 2000a). Some relationships between phonological processes and the ability to mark syntax have also been noted. Himmelwright-Gross, St. Louis, Ruscello & Hall (1985) looked at 144 children in grades 1-7 with either multiple error articulation difficulties or residual errors and a control group. Although they found no differences between the three groups on mean length of utterance, the multiple error group used significantly fewer noun and verb phrases than the other groups. Smit and Bernthal (1983) subgrouped a small sample of children with speech difficulties into those who tended to omit consonants and had a limited inventory ('syllable reducers', n=6) and those who preserved syllable shape but made errors of substitution ('substituters', n=11) and compared them with a control group. The syllable reducers made more errors than the substituters on some language categories, e.g. they omitted more functors and substituted pronouns. No differences were found on a receptive language task. Interestingly, speech perception was also tested. Both speech disordered groups made significantly more errors than controls on minimal triples where initial voiced and voiceless and clustered stops were contrasted. Although the relationship between speech and language skills is accepted, it is unclear from these studies whether there is a co-occurrence of these difficulties or whether one exerts a causal role on the other. Paul and Shriberg (1982) explored this by analysing 30 transcripts of children with speech difficulties, aged 4-8 years. They found that 67% of the sample showed syntactic delay that was independent of phonological deficits while 20% of the sample had a syntactic deficit that could be directly attributed to phonological simplifications. For instance, the use of morphological markers was restricted by final consonant deletion.

The relationship between speech and language skills is thus a complex one and one that needs to be considered in order to understand speech difficulty. Phonological processing is part of a larger language system and is therefore likely to be influenced by these higher levels of language organisation (Hoffman, 1992). The role of language skills has also been proposed as being predictive of the development of written language skills in children with speech/language difficulties (Catts, 1993; Bishop & Adams, 1990). However, studies that contrast children with only speech difficulties compared to children with additional language difficulties in their phonological processing and literacy skills, are contradictory in their findings for the role of language. Bird, Bishop & Freeman's subgroup analysis of 31 5-year-old children found that additional language difficulties did not significantly impact on developing phonological awareness ability or on later literacy development, when compared to matched controls. However, the results have been interpreted by Snowling, Bishop & Stothard (2000) to show that in absolute terms, the speech-only group was scoring better than those with additional language difficulties.

Other evidence that phonological processing skills was not differentially impaired by subgroup was reported in a cross-sectional study by Leitao, Hogben & Fletcher (1997). They recruited children on the basis of having speech-only difficulties, language-only difficulties or mixed difficulties. Compared to children with only speech difficulties, children with both speech and language difficulties (their 'mixed' group) looked significantly more impaired on only one measure of segmenting/blending. There was no significant difference between the two groups on measures of invented spelling, deletion, rapid automised naming or multisyllabic word repetition. The authors observe that on the three phonological awareness tasks (invented spelling, deletion and segmentation /blending) the performance of the speech-only group was subject to a bimodal distribution, with some children in this group showing poor performance, while others scored within normal limits. The lack of subgroup differences in the Bird et al. (1995) study and the bimodal distribution highlighted in the Leitao et al. (1997) study suggest that subgrouping by speech/language may not be an effective way of differentiating subgroups according to phonological awareness ability.

However, recent evidence from Lewis, Freebairn & Taylor (2000a) shows a more clear-cut distinction between children with speech-only compared to speech/language difficulties in a study of 52 5-year-old children who were followed up at 8/9 years. The subgroups performed significantly differently on phonological awareness and literacy skills. Although analyses were controlled for performance IQ, without the benefit of matched control groups, as used by Bird et al., it is difficult to interpret these results. When Bird et al. reported results relative to controls, no significant differences were noted. Nonetheless, significant differences were also noted by Lewis et al. on initial speech tasks and follow-up measures of multisyllabic word repetition, nonword repetition and expressive and receptive language tasks. Examining the speech and language skills of these subgroups is of importance in order to explain varying speech development, and what factors might mediate speech development and speech outcome. Not only would this elucidate the role of language, as well as other potential factors in the course of a speech disorder, it would serve important clinical objectives in the identification and prediction of persisting speech difficulties. Further, a better understanding of the development of speech skills, in relation to language ability, will form a firmer basis for explaining the development of phonological awareness and the acquisition of literacy skills. The developmental perspective on speech disorders is explored in the next section.

1.7. Development of the speech problem

The changing nature of speech disorders is an important theoretical challenge to our understanding of the condition. For instance, phonological approaches take account of normal phonological development by classifying children as having delayed or deviant speech in relation to the error patterns of normally developing children (Grunwell, 1987). A developmental perspective has also been taken by psycholinguistic researchers through single case studies (Stackhouse & Wells, 1993; Vance, 2001) that describe the changing nature of children's speech output skills, their ability to process speech input and to develop phonological awareness skills. Stackhouse and Wells (1997) propose a phase model of development, where children move systematically through a number of stages. A model of speech disorder must have a developmental perspective at its core, not only to further our understanding of the nature of the disorder, but also to add to our knowledge about the course it takes. A developmental perspective therefore is essential for both description and prediction: parents and professionals want to know the likely outcome of a child's speech difficulties. In addition, there has been growing concern that children with speech difficulties may be more at risk of developing literacy problems when they start school, although the issue of heterogeneity muddies our understanding of which children from this population might be most vulnerable (Bird et al., 1995;, Larrivee & Catts, 1999).

There have been several longitudinal studies of children with speech *and language* difficulties (Bishop & Edmundson, 1987a; Bishop & Adams, 1990; Haynes & Naidoo, 1991; Catts, 1993) as well as longitudinal studies looking at the phonological awareness and/or literacy development of children with primary speech difficulties (Bird et al., 1995; Webster, Plante & Couvillion, 1997; Larrivee & Catts, 1999; Lewis, Freebairn & Taylor, 2000 b). Longer-term investigations of the disorder, which examine subgroups, also necessitate the examination of the stability of subgroups over the course of development. This has been examined in the area of SLI (Conti-Ramsden & Botting, 1999; Beitchman, Wilson, Brownlie et al., 1996).

In studies of children with speech/language difficulties, language skills were found to be an at-risk factor of longer-term difficulties. A longitudinal study by Bishop and Edmundson (1987a) of children with SLI found that initial levels of language difficulty were related to later language outcome, though not to later speech skill. In a related paper, Bishop and Edmundson (1987b) found no evidence for any differences in rate of speech/language development between children with speech/language impairments and controls. Johnson, Beitchman, Young et al. (1999), in a fourteen-year longitudinal study that assessed children with speech/language difficulties at the ages of 5, 12 and 19, found better long-term outcomes for children with isolated speech difficulties than those with language difficulties (who could also have speech difficulties, but not necessarily). However, they were more likely to have subtle speech difficulties than those who were in the language impaired group. These studies find that long-term prognosis is poorer in a child with language difficulties compared to a child with speech difficulties. However, the group defined as having 'language' difficulties is often heterogeneous in terms of the inclusion of children who also have speech difficulties. It is therefore unclear whether prognosis is indeed related to language difficulties or whether it is the combination of speech and language difficulties that is central.

The longitudinal study by Bird et al. (1995) which did subgroup in this way, did not specifically examine the relative outcome in terms of speech/language performance. It focused on literacy outcome, although reported means on a measure of percentage of consonants correct indicate poorer levels of speech skill at one and two year follow-up for the speech/language subgroup. Lewis et al. (2000a) examined speech and language outcome and, although they found significant differences on complex speech skills at age 8/9, a comparison across subgroups of children classified with an articulation disorder just missed significance.

There is thus evidence that children with primary speech difficulties who are followed up at a later date, are likely to have poorer language skills and persisting speech difficulties (Felsenfeld, Broen & McGue, 1992). However, to date, there have been few longitudinal group studies of children with primary speech difficulties, rather than descriptions of the population as a whole, that look for predictors or clinical markers of disordered speech development from a wide range of measures. In 1994, Shriberg, Kwiatowski & Gruber commented on current knowledge:

> "*Notwithstanding 60 years of research efforts to develop valid predictive instruments for developmental phonological disorders, there currently is no clinically effective procedure to predict which children will normalize with or without intervention*" (p. 1129).

Shriberg and colleagues have conducted a number of studies in this area. In 1988, Shriberg and Kwiatowski argued that the severity of a child's speech difficulty was associated with an ongoing need for speech therapy. Another study by Shriberg, Kwiatowski & Gruber (1994) looked at 'short term normalization' of 54 five-year-old children who had been classified as speech disordered one year earlier. Rather than make comparisons with a control group, Shriberg et al. compared children with speech difficulties who 'normalized' and those who did not. Wide-ranging measures were taken including a speech profile of English consonants, demographic data on gender, age, birth order, number of children in family, father's and mother's education, data on hearing, developmental history, oromotor skills, cognitive-linguistic levels and amount of intervention. In all, only 8 of 87 risk factor contrasts showed a significant difference between the groups and in 6 of these the normalised group showed more involvement. The two measures that did show the non-normalised group to be performing more poorly, palatine tonsils and pharyngeal structure, are not readily interpretable. While the study offers detailed description of performance in the areas assessed and identifies the proportion whose speech normalises by age 5, they were unable to find any significant predictors of this short term normalization.

At the start of this chapter, the issue of varying prevalence rates of speech disorder was discussed, and the variation was accounted for by the heterogeneity found in the population. The matter of defining the natural history of the disorder is even more complex. Natural history is defined as "*the prognosis of a condition in the absence of intervention*" (Law, Boyle, Harris et al., 2000, p.166). Given that many children will be receiving speech and language therapy, or may be receiving other forms of input, the measurement of natural history is problematic. Indeed, in the systematic review of the literature for 1967-1997 by Law et al. (2000) on prevalence and natural history, only three studies of children with speech-only delay were included of children who were not receiving intervention and so met the criteria for inclusion in the review. Given this difficulty of measuring natural history and prognosis, Law et al. (2000) recommend that researchers shift from an emphasis on natural history, to a model of predictive risk. Such a model would require the identification of key factors that are predictive of later status. Rather than advocating a theoretical quest to identify causal factors, such an approach is clinically driven because it can produce prognostic information, and can also take account of factors of intervention in the prognosis. The reviewers conclude that:

> "*There is a need for large-scale cohort studies to tease out the relationship between component parts of the equation across time*". (p.184).

This type of approach of examining relationships between skills over time is needed to understand the nature of developmental conditions, such as speech disorder and could help address the issues of heterogeneity and of prediction of later speech/language abilities.

1.8. Outline of thesis

The central themes of the heterogeneity of the speech disordered population, the ways in which we identify later speech outcome (i.e. developing a model of predictive risk) and the way speech processing skills (both input and output) develop, are investigated in this thesis (Chapters 4, 6 and 7). These themes are examined through a longitudinal design (described in Chapter 3) that allows for children's speech processing skills to be tracked over time, between the ages of 4 and 6. Other potential factors of influence, including family history of difficulties and therapy input, are described and explored (Chapter 5). Speech processing skills are investigated in more depth in the latter part of the thesis, through examining relationships and differing patterns of performance between measures of speech output and speech input. The following chapter presents a literature review focusing in more detail on speech processing skills in order to set this theme in context.

Chapter 2
Speech processing skills

2.1. Relationship between speech processing skills

A linguistic approach to the description and analysis of speech disorder, i.e. conducting phonological analyses of speech samples, was the established theoretical approach of the 1980s. However, a more current trend in the UK is to broaden this approach by specifically examining different aspects of the speech processing mechanism in an approach influenced by psycholinguistic theories. The focus underlying processing skills and demands has arisen because phonological description is seen as limited in its ability to offer theoretical explanation, and classifications based on it may be misleading (Stackhouse & Wells, 1997). Rather, phonological simplification processes can be explained by problems that have arisen at different levels or modules of processing (Williams & Chiat, 1993). For example, a phonological analysis cannot offer an explanation for differences in performance when word stimuli are compared to nonword stimuli. This type of approach can also encompass findings on motor output and auditory processing deficits that have been reported in the literature on speech disorder. Stoel-Gammon (1991), for example, proposes a three-tiered explanatory model of speech difficulties that covers input, output and cognitive skills. This chapter will review the evidence for speech processing deficits in children with speech difficulties. It will highlight the current imbalance in the field towards contrasting processing levels and it will be proposed that associations between processing levels should also be examined. It will also review the evidence that speech variability should be considered as a core issue in the study of speech processing skills.

Children with similar speech errors in terms of their phonological simplification processes may in fact have different underlying processing deficits (Stackhouse & Wells, 1997). This work has, to some extent, been influenced by the cognitive neuropsychological models applied in acquired language disorders that take a modular view of the linguistic processing system in the form of box and arrow diagrams (e.g. Ellis

& Young, 1988). Some researchers have adapted directly adult models of speech/language processing (Bryan & North, 1994).

Developmental psycholinguistic models and explanations have generally emerged from studies of individual cases, that compare across speech processing tasks, with some using normative data to aid interpretation. Recent models include those by Hewlett (1990), Dodd (1995), Stackhouse and Wells (1997), Hewlett, Gibbon & Cohen-McKenzie (1998) and Chiat (2000). As with phonological analysis, a psycholinguistic approach lends itself well to a case study methodology. A number of case studies (Chiat, 1983; Brett, Chiat & Pilcher, 1987; Leahy & Dodd, 1987; Bryan & Howard, 1992; Bryan & North, 1994; Hewlett et al., 1998; Stackhouse & Wells, 1997, 2001) describe in detail an individual child's performance on a range of input and/or output tasks in order to examine the level/levels of speech processing that are problematic for that particular child. In the cases described by Stackhouse and Wells (1993; 1997), strengths as well as weaknesses in speech processing are emphasised, in view of planning appropriate therapy that can target weaknesses, but can also take account of intact skills in order to develop compensatory strategies. The aims of these models are to increase our understanding of speech and language processing mechanisms and the precision with which we can describe the nature of a speech problem. By promoting a hypothesis-driven approach they therefore provide an important tool in both the assessment and treatment of speech disorder. From a more theoretical perspective, differentiating performance and reporting unusual processing patterns in individuals sheds light on normal speech processing architectures.

Group studies of clinical populations have also been carried out to locate deficits within subgroups of the speech disordered population, rather than within one individual (Dodd, Leahy & Hambly, 1989; Williams & Chiat, 1993). These studies look for common underlying speech processing difficulties across subgroups of children. They aim to show different patterns of dissociation according to the type of surface speech difficulty. Here the emphasis is on the relationship between surface characteristics of underlying speech processing skills at a group level. This chapter will review studies using both a group and single case study methodology. Comparison of competing explanations for differences in performance between psychoinguistic tasks will be made.

2.2. The influence of stored representations on speech production

2.2.1. Single case studies

Single case studies have had an arguably larger impact, both clinical and theoretical, than group studies on our understanding of this population's speech processing skills and have had considerable influence, particularly in the development of precise modelling of the developmental speech processing system. This reflects a similar influence of cognitive neuropsychology case studies in the acquired language disorders literature. A case study methodology can be used to describe the speech processing skills of individuals and has highlighted the variation in underlying speech processing skills between children with different speech/language difficulties. No assumption is made that children fall into subgroups, as is made in the group studies reviewed later in this chapter. On the contrary, Stackhouse and Wells (1997) have discouraged the use of a group methodology as this is likely to mask the individual processing capacities of children. Averaging across children within a group can mask individual variation (Temple, 1997), which can result in misleading interpretations.

When applied to longitudinal cases, this type of methodology is also a useful tool in addressing the complex developmental perspective of speech processing skill. Speech processing deficits and skills in any particular child are likely to change over time as a child develops compensatory strategies and as more demands are placed on the child. The challenge of addressing development within a psycholinguistic framework is recognised. Chiat (1997) observes that the psycholinguistic enterprise appears to be, "*impossibly complicated by what we might term the 'developmental dimension'*" (p.3). Complications arise from the need to make valid comparisons to the developing speech processing skills of the normal child, and in the quest to understand the knock-on effects of a deficit in one area on the development of other processing skills.

Nonetheless, the careful comparison of speech processing tasks in order to examine the effects of speech processing skills on speech output performance has had some success. Comparison of word and nonword repetition has been one such area of research focus. Generally, word repetition performance exceeds nonword repetition in normal development (Vance, Stackhouse & Wells, 1995). The reverse pattern of nonword repetition being better than word repetition in some individuals with speech difficulties has generated interest and hypotheses about effects of lexicality on word processing and on the underlying nature of some children's speech processing deficits. Two case studies (Bryan & Howard, 1992; Hewlett et al., 1998) present data which suggest an influence of lexical factors on speech production. Both studies adopt a psycholinguistic framework in order to explain how phonology is mediated by different speech processing demands. The studies are particularly important in exploring how inconsistency can be apparent in children's phonology and how change occurs in the system.

Bryan and Howard (1992) present the case of DF aged 5, who is described as having '*frozen phonology*'. Presented with matched stimuli, DF was much better at repeating nonwords than repeating real words and naming pictures. Similarly, Hewlett, Gibbon & Cohen-McKenzie (1998) present Murray, another 5-year-old who performs differently on velar production depending on the type of task (although the number of items are small and the items are not matched). In order to explain the phenemenon, Bryan and Howard posit two lexicons for input and output. For nonword repetition, the child filters the input perceptually to the input representation and then applies realisation rules to create an output representation, without recourse to stored representations. DF has a relatively good performance in nonword repetition. The authors suggest that this shows he has no obvious perceptual difficulties in managing the input (despite poor performance on a standardised auditory discrimination task), nor much difficulty on the output side in terms of realisation rules. Having ruled out these deficits, the authors hypothesise that poorer performance on real word repetition (as well as naming) is due to deficient output representations. In summary, DF is not updating his phonological output representations, hence, his phonology is described as '*frozen*'. Hewlett et al.'s (1998) explanation of Murray's performance is similar. Better performance on nonword repetition is partly attributable to the salience of perceptual properties in a repetition task as opposed to a naming task (where there is no auditory input) and also because the lexicon can be bypassed. The child therefore is not influenced by the stored representation and can continue with his articulatory routines. Conversely, the authors suggest that word repetition is disadvantaged by the mandatory accessing of the lexicon even though it is not necessary to access a representation in order to do the task. Superior nonword repetition is likely to be confined to those sounds that are stimulable but not well established in the child's system. The implication is that with updating of stored representations, word repetition would realign with nonword repetition. Where Hewlett et al. (1998) differ from Bryan and Howard is in their rejection of a 2-lexicon model. The output lexicon in this type of model is supposed to have a production-based store yet the authors do not believe an output lexicon can account for variable realisations, a common feature of disordered speech. They instead posit phonological representations that are associated with perception more than they are associated with production. They reason that if a phonological representation is weighted to perceptual features one does not then need to assume accurate articulatory knowledge:

> "*Perception of the relevant phonological categories is logically necessary for the establishment of correct phonological representations but the ability to produce them is not*" (p.169).

Stackhouse and Wells (1997) deal slightly differently with the issue by describing a lexical representation that is made up of different components. Within the lexical representation is the phonological representation which stores information that is principally auditory. Semantic and grammatical information of the word will also be stored here, as well as a motor program which stores information about articulatory gestures and relates most closely to the notion of output representations. Unlike Hewlett et al., the phonological representation is not just weighted to input, but mainly is an input store. If a child with speech difficulties demonstrates accurate phonological representations by good performance on a Locke-style auditory discrimination picture task (see discussion of Locke's 'speech production-perception task' in Chapter 1, Section 1.5.3) and also has age-appropriate auditory discrimination skills, then speech output difficulties must be due to other levels. For example, the difficulties could be attributable to the process of retrieval of the representation and/or creating motor programs (an output representation) and lower level articulatory problems (Stackhouse & Wells, 1993).

Whilst Bryan and Howard present a case that strongly supports a deficit at the level of output representations, Hewlett et al. are more cautious in reaching conclusions about Murray's difficulties. They are sceptical about being able to identify a single factor that will explain a child's phonetic output. Stackhouse and Wells (1993) also argue that multiple factors may be involved in their study of a 5-year-old girl, Zoe. They specify quite precisely the three levels of processing from which Zoe's speech difficulties arise. This raises the issue of heterogeneity in a different form. As previously discussed, a group of children with speech difficulties exhibit a range of speech output difficulties which may arise from a range of speech processing problems. Even within one child, specifying a range of speech processing deficits may be necessary to account for that child's speech output difficulties. This type of detail could be argued to make therapy planning more targeted and therefore more effective. However, changes in the speech processing system over time complicate the picture, as earlier skills influence the development of later skills. Identifying one or more processing deficits at one time point cannot capture how the deficit(s) developed.

Both Bryan and Howard and Hewlett et al. present children who seem to show a quite distinct pattern of performance on tasks that manipulate lexical status. However, the distinctness of their performance cannot be categorically concluded. No control groups were used. It is unknown how common this pattern is in children with speech difficulties, though superior nonword repetition is unusual in normally developing 5-year-old children (Vance, 2001). Nonetheless, Bryan and Howard suggest that they may have chanced on a pattern of performance that could be relatively common. It could even reflect a normal pattern of development observed by Stackhouse and Wells (1997) in very young children. However, Hewlett et al. are more cautious on whether this could be a common occurrence in children with speech disorders. On the whole, they conclude that it is more likely that nonword repetition would be more difficult than word repetition and, in particular, that performance might be influenced by a child's stimulability for specific sounds. Both children in these case studies were also reported to be making significant progress with speech. One possibility is that the children are in the process of resolving their difficulties and that the pattern of performance simply reflects a stage in this process. Evidence from a group study of children with speech difficulties does not show this to be a common pattern: Williams and Chiat (1993) did not find different word/nonword repetition performance, with neither task producing a superior performance.

2.2.2. Group studies

Identifying patterns of performance in an individual elucidates processing routes and processing architectures. It also is of clinical significance in planning and targeting therapy. Replicating these patterns across individuals would support a recasting of the nature of speech difficulties as a core processing deficit or several processing deficits. The following section reviews the evidence from group studies.

Several group studies have examined the performance of children with speech difficulties on different types of speech processing tasks (Dodd, Leahy & Hambly, 1989; Williams & Chiat, 1993; Bradford & Dodd, 1994; Bradford & Dodd, 1996). Rather than subclassify according to processing patterns, the principal aim of these studies has been to validate the existence of certain predetermined classifications or subtypes of speech difficulty: if differences can be found between underlying speech processing skills of the proposed subgroups, their existence as independent theoretical and clinical entities is validated.

Williams and Chiat (1993) examined whether children defined as having delayed vs. disordered phonological development performed differently on a range of speech output tasks, i.e. whether the consistency or inconsistency of errors across tasks could be differentiated between groups. The children were aged between 4;09 and 6;11. Nine were classified as phonologically delayed and 12 as phonologically disordered. The output tasks were: naming, sentence repetition, word repetition and nonword repetition. The same 60 items were used across the three tasks using real words, and matched nonwords were derived for the nonword repetition task. There was a significant interaction of task x group. Children with phonological delay obtained similar scores across all tasks. Children with phonological disorder, however, displayed a different pattern. First, they made more errors overall than the other group. They were better at repetition than naming; and better at single word/nonword repetition than sentence repetition. They showed little difference between word and nonword repetition, indicating that the pattern of performance identified by Bryan and Howard (1992) may be the exception rather than the general pattern. However, the group results belied considerable variation in the phonologically disordered group. Six members of this group showed a more consistent profile compared to the other six who showed a large discrepancy between repetition and naming. The authors concluded that different patterns of performance on these tasks indicate different underlying difficulties. Children whose naming and repetition skills are in line do not have representational difficulties or lower level articulation problems, so their difficulty must lie in motor programming. Children with an inconsistent error pattern do show problems at the representational level either with lexical representations or with the accessing of lexical representations. However, these different patterns did not correspond exactly with the distinction between delayed and disordered speech as predicted, thus not validating a clear relationship between subgroup and pattern of processing.

Dodd, Leahy & Hambly (1989) conducted a study that was motivated in a similar way to the Williams and Chiat (1993) study. They hypothesised that there were different patterns of performance for three proposed subgroups of 4-year-old children with speech difficulties. Three speech output tasks, of imitation, naming and picture description, were used to investigate different patterns of performance across the three subgroups: those with delayed speech, those who made deviant consistent errors and those who made deviant inconsistent errors.

Here, the motivation for the selection of the subgroups was to extend the subdivision of delayed versus deviant or disordered classification that was current in the literature of the time (and indeed the classification that was later explored in Williams and Chiat, 1993). Dodd et al. observed that the speech patterns of some children with speech difficulties could not be easily described in terms of their phonological processes because some children tended to make many inconsistent errors, pronouncing words differently on different occasions. Thus children with deviant phonological processes were subdivided into whether their speech was consistent or inconsistent on the basis of a phonological process analysis of a spontaneous speech sample. As well as speech output tasks, they also investigated other speech processing skills: their ability to discriminate between their errors and a correct model and the children's preference for legal versus illegal nonwords. Like Williams and Chiat, they also found different patterns of performance on the speech output tasks and the patterns of performance seemed to be differentiated between subgroup.

However, the results must be treated with caution, as individual variation is not discussed (except for the legality test) so it is not clear how homogeneous the subgroups were in their performance on the measures. Children described as having delayed speech performed similarly on the three tasks and also performed better than the other two groups. The deviant consistent group performed better on the imitation task than the other tasks; and the deviant inconsistent group performed better on the imitation task than the naming task, and better on the naming task than on spontaneous speech (picture description). The authors conclude that children with deviant consistent and deviant inconsistent speech have particular difficulty in generating a phonological output either because of a problem with the storage of phonological representations or because the mental operations of planning the output are impaired (abstracting the rules governing the phonological system).

Both these studies explore the relationship between the surface speech problem and underlying speech processing. Additionally, they share similar overall aims to the case studies reviewed in attempting to examine underlying speech processing skill by comparison of tasks that tap different aspects of the system. By seeking to differentiate the speech processing performance of subgroups defined by phonological characteristics, the group studies aim to validate this way of subgrouping children with speech difficulties.

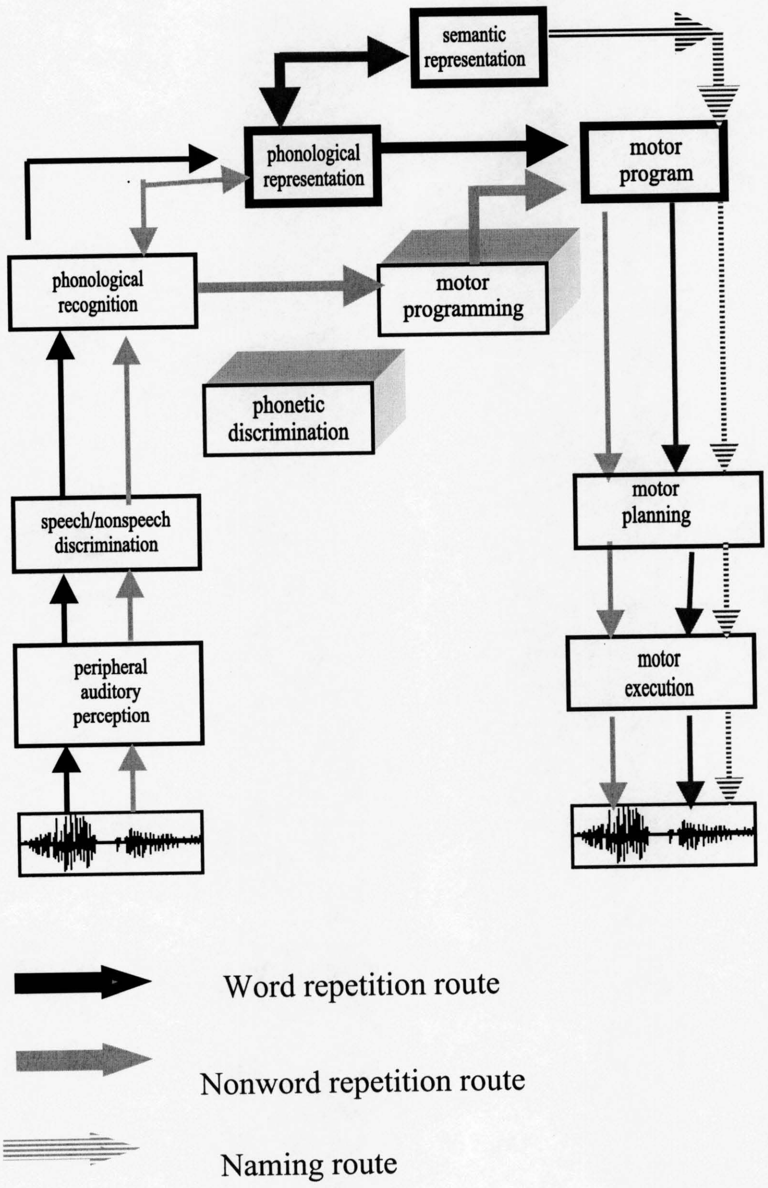
2.2.3. Interpretation of task comparisons

The studies differ in their interpretations of the patterns of deficits in the tasks. Dodd et al. argue that children in their consistent and inconsistent subgroups have difficulty abstracting hypotheses about the rules governing their phonological system or problems with storing phonological representations. This difficulty then leads to a reduced ability to generate accurate motor plans and so poor naming skill. Williams and Chiat argue it may be difficult to differentiate between an incorrect abstraction for the execution of a motor plan and a problem with motor planning itself. Stackhouse and Wells (1997) also agree that it may be difficult to pinpoint what such a discrepancy means in speech processing terms. If repetition is better than naming, they suggest that the problem must be with imprecise phonological representations or incomplete motor programs or that there are poor links between lexical representations and the motor program. The comparison of this pattern of performance with different patterns is a useful one. When naming is in line with repetition, the problem may lie with motor programming (Williams & Chiat, 1993). When naming is better than repetition, input skills may be impaired as, when the child does not need to use auditory skills (i.e. for naming), performance is better (Stackhouse & Wells).

Figure 2.1 illustrates these processing routes according to a model developed by Stackhouse and Wells (1997). Naming, word repetition and nonword repetition routes are marked on the model. Lexical representations are illustrated by the bold boxes, consisting of a stored phonological and semantic representation and a motor program containing the blueprint for producing a stored word. The nonword repetition route shows how the representations can be bypassed and shows the need to create a new motor program, through the motor programming device, as a nonword will have no stored representations. Naming, whose route starts at 'semantic representations' does not require any input skills. A stored motor progam will be accessed in order to name accurately. Word repetition, like nonword repetition, requires input processing. In addition, it will generally require access to a stored phonological representation and a stored motor program. However, it is possible for a word to be processed through a non-lexical route. By contrasting such speech output tasks with different processing demands, it is possible to isolate within this framework where a particular deficit or deficits of processing may be occurring. The studies reviewed, both group and single case, have this objective.

When no discrepant pattern of performance is identified, a difficulty arises in how one should interpret equivalent performance across task, for example, in the delayed groups in the Dodd et al. study and the Williams and Chiat study. The assumption made by Dodd et al. seems to be that the delayed subgroup, who performs similarly on all the speech output tasks, is following a normal pattern. One of Dodd et al.'s explanations for this subgroup's deficits is that they show neurological immaturity. Williams and Chiat propose that their delayed group do not have a problem with lexical representations or accessing lexical representations, and so must have a problem at a later stage of output processing: when forming a motor program.

Figure 2.1.
Stackhouse and Wells' speech processing model (1997): Naming, word and nonword repetition routes



However, neither study assesses the performance of normally developing children on the measures used so it is not clear whether a normally developing pattern would be an equivalent performance across tasks. The study by Vance et al. (1995) comparing naming, word and nonword repetition in normally developing children aged 3-7 found that children do not perform similarly across all tasks (with matched items used across tasks). Word repetition was significantly easier than the other tasks measured (articulatory naming, nonword repetition and sentence repetition). Additionally, the pattern of performance changed with age: the discrepancy between word and nonword repetition widened with increasing age. It seems that the delayed groups in the group studies may not then necessarily be following a normal developmental pattern, whilst the other subgroups may look more similar to controls. Without control data in these studies, it is not possible to assess whether the disordered subgroups show the same or different patterns of performance between naming and repetition compared to normally developing children.

2.3. The influence of stored representations on speech input performance

The contribution of speech input processing also needs to be considered directly. The co-occurrence of speech input difficulties and its possible relationship with speech output skills was reviewed in Chapter 1. However, surprisingly few group studies have incorporated tests of auditory processing in their battery. Williams and Chiat did not assess input skills in their study but hypothesise that this area is unlikely to be a problem as verbal comprehension was not affected and repetition skills (where auditory processing is required) was superior to naming. Dodd et al. come to similar conclusions on the basis of a task testing the participants' recognition of their own mispronunciations. In this task, each child was presented with single words, some of which were recordings of that child's speech production error and some of which were spoken accurately by an adult. For each item, the child had to identify the word by pointing to one of four pictures that were presented. All subgroups made more errors identifying their own form compared to the adult's production, i.e. they were able to identify correct productions, implying acceptable auditory perception and accurate phonological representations. Since the task is designed around individual children's errors, a control group was not used. However, as with the speech output tasks, one cannot discount input processing without using a task that would allow comparison to normally developing controls.

There are certainly few studies using this type of approach that examine input processing and few group studies that address this in any detail in either normal or atypical development (with the exception of Dodd et al.'s study which included one measure of input). Contrasting amongst input processing tasks could be potentially informative of the nature of children's speech processing difficulties. It could shed light on whether children who have difficulties in this area have problems at a higher, representational level or a lower level of auditory processing. In relation to speech output skills, it would also be interesting to examine whether bottom-up or top-down processing strategies are used.

2.4. Speech variability

Speech input processing is not only concerned with how children discriminate sounds within their language environment or how they learn to represent and encode phonetic or phonological input. A fundamental aspect of speech processing is the way in which children extract phonological information from variable speech input and the way variability might be encoded or represented within the phonological system. If phonological processing is the "*gateway to language*" (Black, 1997, p.242) and delivers input to other language modules, then examining how a variable speech signal is mapped onto the phonological processing system is a central issue. Stackhouse and Wells' (1997) speech processing model describes a processing module: "phonetic discrimination" where unfamiliar or variable input may be discriminated and mapped onto familiar, phonological material (see Figure 2.1). Processing of speech variability is hypothesised to be another potential area of vulnerability for those whose speech is developing atypically (Nathan, 1994; Stackhouse & Wells, 1997).

How listeners process variability is a question that has to be addressed by any model of speech processing, including models of normal and atypical speech development. Forrest, Chin, Pisoni, and Barlow (1994) report a study of how children with speech difficulties process word lists spoken by a single speaker compared to multiple speakers. They argue that since our understanding of the relationship between speech production and speech perception in children with speech disorders is limited, it could be profitable to examine how these children process speech variability.

As Ryalls and Pisoni (1997) observe, research into speech variability poses many questions about how children acquire language in "*real-world contexts*" (p.450). However, our knowledge even of how adults and normally developing children process variation is limited. There is evidence that speech variability does influence one's ability to process speech. The cognitive load might be lower for a listener processing a single speaker compared to many speakers: familiarity with a particular speaker or voice has been found to increase word identification (Nygaard & Pisoni, 1998) and children (aged 3-5) and adults are better at word identification when the stimuli are presented by a single speaker as opposed to multiple speakers (Ryalls & Pisoni, 1997).

Accent variation is one type of cross-speaker variability. Chambers and Trudgill (1980) define accent as,

" *The way in which a speaker pronounces, and...refers to a variety which is phonetically and/or phonologically different from other varieties*" (p.5).

Accent variation is particularly interesting to examine in relation to children's speech processing systems, since young children's learning of their own language integrally involves establishing the phonological systems and phonetic realisations of a particular accent. The child acquiring his/her native language must, on the one hand, learn a phonological system corresponding to their environment, and, on the other hand, develop the ability to process other accent systems to which he/she is very likely to be exposed.

There is evidence that young normally developing children are generally able to acquire new/second languages proficiently and they also can quickly learn the accents of new languages (Long, 1990). This ability to accommodate to new accents also occurs within their own native language, revealing a remarkable capability to adjust to language variation and, in particular, to acquire the segmental and prosodic features of new accent systems (Chambers, 1992; Payne, 1980). The extent of this proficiency is likely to be related to the age of the speaker. A more native-like accent is acquired the younger the speaker is when the new language/dialect is learned, although adaptation can also occur in adults (Munro, Derwing & Flege, 1999). The study of developmental factors in relation to accent is thus central, and the relationship may reflect a sensitive period for language acquisition (Scovel, 1981). The importance of age in the acquisition of new accents is well attested and the extent to which accent variation affects adults' detection, processing and understanding of speech has also been explored (Flege, 1984; Labov, 1989; Schmid & Yeni-Komshian, 1999). An understanding of normal development is needed in order to explore accent processing as a possible locus of processing deficit in children with speech difficulties.

A study by Nathan, Wells & Donlan (1998) provides some evidence that accent variation can disrupt access to lexical representations in normally developing children. They tested children aged 4 and 7 years on their ability to repeat and define words spoken in their own London accent and in an unfamiliar accent - in this experiment, the accent of Glasgow in Scotland. Further data using the same materials and procedure has subsequently been collected from 5-, 6-, 8- and 9-year-olds (Collins, 1998; Pate, 1998). Children in all age groups performed significantly less well on the unfamiliar accent in both their ability to repeat and define words appropriately. Older children performed significantly better than younger children on the tasks and showed a qualitatively different pattern of performance. In the definition task, while most children tended to make errors of incorrect lexical access, based on phonetic confusions (e.g. defining the Glaswegian realisation of BEAR [beɹ] as 'my dad drinks it', i.e. 'beer' rather than BEAR), younger children made more errors of failed lexical access (for instance, defining CHURCH as 'eating'). An age-related difference was also apparent in the repetition task: younger children (particularly 4-year-olds) were more likely to make phonetic responses that were imitative of the Glaswegian accent, e.g. CHURCH, Glaswegian stimulus [tʃʌɹʔtʃ] realised as [tʃɔʔtʃ] or [tʃɒɹʔtʃ], rather than make correct phonological repetitions in terms of their own London accent, e.g. [tʃʲɜːʔtʃʲ]. In the youngest age group, these types of phonetic responses were accompanied 61% of the time by failed lexical access (i.e. the child either gave no accompanying definition or a highly implausible definition). These phonetic responses demonstrate that young children are influenced by the phonetic form of the variant input, choosing at times to imitate some aspects of the new form in the repetition task rather than process it within their own system. In contrast, older children are much more likely to process unfamiliar phonetic stimuli within their own system.

It seems likely that intact auditory discrimination skills and accurate phonological representations are both important in performing this type of processing. If, as proposed by Hintzman (1986), phonological representations are characterised by a high level of detail, consisting of multiple traces of speech input, then processing accent variation could be dependent on how well specified the phonological representation is, i.e. whether a trace exists that corresponds to the particular variant accent form that the child is presented with. On the other hand, phonological representations can be viewed as abstract and relatively underspecified, thereby able to accommodate a range of variant input forms (Stackhouse & Wells, 1997, pp.158-159). Under this scenario, when the child is exposed to an utterance in an unfamiliar accent, phonetic discrimination skills would be involved at an early stage of input processing (as shown in Figure 2.1).

Both bottom-up and top-down processing factors may play a role in the development of phonological representations and also in the development of the ability to understand words spoken in unfamiliar accents. As children with speech impairments are more likely to have deficits in auditory discrimination, in vocabulary development, or in both, it can be hypothesised that they are likely to have difficulties in processing and comprehending unfamiliar accents.

2.5. Dissociations and associations

Section 2.2 reviewed group and case studies that focus on levels of speech processing, with an emphasis on comparison of speech output tasks. In typical cognitive neuropsychological tradition, these studies and the models that accompany them emphasise differences between tasks, and these differences can be said to represent dissociation in performance. Identifying dissociations and double dissociations validates the existence of separate processors. Identifying patterns of dissociation at a group level would also show that children with speech difficulties share a common speech processing deficit. Given the review of the literature on the issue of heterogeneity, such a uniform processing deficit is very unlikely at a group level. Nonetheless, describing speech processing deficits at a group level is an important enterprise. If certain patterns of performance are very rare (e.g. nonword repetition being better than word repetition) then these patterns remain of interest at a theoretical rather than clinical level (Dodd, 1995). Additionally, by examining these patterns of performance from a developmental perspective, it may be possible to account for some of the observed heterogeneity. Diverse patterns may be accounted for by a single earlier factor. Alternatively, patterns of performance may remain stable over time, lending weight to a core deficit hypothesis.

Whilst there has been an emphasis on uncovering distinctive patterns of performance, the study of associations between components of the speech processing system has been relatively neglected. The dissociations that the distinctive patterns reveal are the principal means of discovering the underlying architecture of a processing system (Temple, 1997). However, dissociations are likely to be extremely rare in a developing system (Hulme & Snowling, 1992; Bishop, 1997). Instead, early cognitive development can be seen as an interactive system, from which modularity (i.e. dissociable functions and modules) emerge (Karmiloff-Smith, 1998). An examination of associations therefore could shed light on the development of a processing system, allowing the interactive nature of speech disorder to be explored.

Association of skills is apparent in this population. Other language difficulties can commonly co-occur with speech disorder. The review of the literature on speech input also showed that speech input difficulties can be associated with speech output difficulties. Whether these co-occurring difficulties are associated in a theoretically defined way is of particular interest. Associations between skills may reflect underlying causal relationships in development. Chiat (1997) recognises that, within a psycholinguistic perspective, exploration of interactions between modules and levels of representations becomes particularly important in describing a developmental process. For a dynamic and changing system, a study of associations becomes as important as a study of the dissociations of its components.

Indeed the shortcomings of using a cognitive neuropsychological or psycholinguistic approach have been acknowledged for some time in the study of speech disorders. Bryan (1995) acknowledges that box-and-arrow models are not designed to deal with disorders that are developmental and hence likely to be interactive. She also raises issues about how to relate assessment findings to therapy. Stackhouse and Wells

(1996) also criticise the "*inherent rigidity of information processing models*" (p.9). Such observations have lead researchers to other types of descriptive and explanatory frameworks. Stackhouse and Wells (1997) have developed a phase model of speech processing development to add a developmental perspective to their box-and-arrow model. Others favour theories that take account of interactions within a dynamic and developing system. For example, Chiat (Chiat & Hunt, 1993; Chiat, 2000) describes data that is compatible with interactive or connectionist models of language processing, where different components of the speech processing system "*cascade forwards – and perhaps even backwards*" (Chiat, 2000, p.107). Connectionist theories explicitly address the issues of development, interaction and the learning process (Elman, Bates, Johnson et al., 1998). Connectionist modelling is neurally inspired and simulates how learning takes place through changes in the strengths of connections between neurons and thus emphasises the influences between them. Knowledge and learning is seen in terms of parallel distribution, i.e. knowledge representations are distributed across a network of processing units, and learning takes place in parallel across these distributions, so emphasising interactions and not separable processing units.

A connectionist perspective can also overcome some of the difficulties of relating psycholinguistic assessment to therapy planning because therapy can be construed as a process of exploiting these interactions (Chiat & Hunt, 1993). In any case, researchers and practitioners working within the field of developmental psycholinguistics (Rees, 2001; Waters, 2001) already incorporate principles compatible with an interactionist approach. Therapy is often eclectic, and uses strengths to augment weaknesses in order to develop stronger links between processing capacities.

Connectionism explores these processes through computer simulations, though this approach has had limited impact in the study of developmental speech disorders to date (however, see Stemberger (1992) for one application). There are other methods that can be used to examine these key issues of interaction and learning. The single case study methodology is limited in its capacity to examine association of skills at an individual level, although longitudinal case studies can begin to explore this over time in one individual (Stackhouse, 1993; Stackhouse & Wells, 1997). Other methods are needed in order to examine interaction and relationships between speech processing skills, and to examine these skills developmentally. Multivariate statistical analysis is a tool that enables examination of converging and competing influences on processing skills at a group level (Bates, Bretherton & Snyder, 1988). Correlation and multiple regression techniques analyse relationships between skills. They can uncover how these relationships might change over the course of development as well as how skills may be differentially related to later developing skills, i.e. they are the means to discover the interactions between processing levels in a developing system. Uncovering associations between certain skills and comparing levels of association between disordered and normally developing groups is, at one level, important descriptive information, with both theoretical and clinical implications. At another level, it may tackle causal relationships between skills, and so highlight the nature of the developing system as well as the mechanisms of change in the developing system. A longitudinal design is one of the principal methodologies of explaining such relationships over time and of examining causal hypotheses (Bishop, 1997; Bryant, 1990). Bishop (1997) promotes the need for more group data to elucidate relationships between skills:

> "*We need group data to establish which patterns of deficit reliably co-occur, which are chance associations, and whether scores are evenly depressed on a range of tests, or whether distinctive profiles can be reliably detected.*" (p.233).

Associations between early developing skills and these skills measured at a later stage could be informative about the *comparative* role these skills play in development. In this sense, the analyses of association and dissociation are compatible, as, through a study of association, one can highlight which components of the speech processing system are most central to an understanding of that system. If two different tasks play different roles in their relationship with a third task, then one could postulate that these two tasks are dissociated in their influence on the third.

2.6. Continued outline of the thesis

The themes of this review chapter are explored in depth through the longitudinal study of children with and without speech difficulties, and through one cross-sectional study. Patterns of performance including specific dissociations and associations of performance are explored in Chapters 7 and 8. More general relationships over time between speech output, input and language skills are analysed in Chapter 9. Processing speech variability is examined in Chapter 10 through a cross-sectional study. The next chapter presents the longitudinal study and its methodology.

Chapter 3
Introduction to the longitudinal study and its methodology

3.1. Introduction

The current chapter introduces the longitudinal study and describes the rationale and methodology of the study, including rationale for task selection, task design, participant selection, core test battery and procedure. Chapters 4 to 9 following this chapter describe analyses conducted on the longitudinal cohort of children with speech difficulties and their matched control group. Chapter 10 describes a further study, using participants selected from the longitudinal cohort, but that is cross-sectional in design.

3.2. Rationale for the study

3.2.1. Speech processing perspective

This study of children with speech difficulties was motivated by a psycholinguistic approach where children's speech difficulties are analysed in terms of their speech processing skills. A primary aim of the study had been to examine the relationship between children's speech difficulties and literacy development, and this aim is dealt with elsewhere (Stackhouse, Nathan, Goulandris & Snowling, unpublished). The focus of this thesis is to examine speech processing skill, removed from a consideration of speech error analysis, phonological awareness or literacy development. Broadly, speech processing was examined through comparing and contrasting performance on tasks designed to tap speech input, phonological representations and speech output skills. These three levels of processing have been explored in various ways in the literature. First, speech input has been highlighted for its role in speech development, as subgroups of children with speech difficulties are impaired in a range of input tasks. Second, stored phonological knowledge has been explored through comparison of output tasks (both single case study and group methodology). These studies (reviewed in Chapter 2) describe in more psycholinguistic terms a role for phonological representations. The examination of these processing components is seen as a way of potentially identifying a core deficit underlying a child's speech output problem, the third element of the speech processing system.

Task design and selection are cornerstones of a psycholinguistic approach. Locke's (1980) meta-analysis of different types of speech input assessment (reviewed in Chapter 1) was taken up by Stackhouse and Wells (1993; 1997), and is reflected in the design of the speech input tasks used in this study. Tasks where picture stimuli are used will require a child to access his/her phonological representations, and so, the accuracy of phonological representations will be assessed in addition to other auditory discrimination skills. Tasks with no pictures may not make use of this stored knowledge; and tasks that use nonword stimuli are even less likely to make use of stored representations, as these stimuli are not represented, though they may be accessed through use of analogy. Similarly, speech output tasks can be designed to assess the role of stored phonological information on speech output performance, e.g. word repetition or naming versus nonword repetition. Through such task comparisons, it has been possible to develop models of processing, such as the one by Stackhouse and Wells (1997) shown in Figure 2.1 of Chapter 2.

In order to make comparisons between tasks, which is such a central tenet of a psycholinguistic investigation, design of these tasks must be considered with care. In terms of design, Stackhouse and Wells (1997; Wells, 1995) advocate the use of matched items across tasks. The same lexical item should be used across tasks employing word stimuli. Nonword stimuli should be manipulated versions of a real word (e.g. by altering a vowel to create a nonword). Word frequency, syllable length and phonological structure should also be considered in designing tasks.

These considerations informed the choice of test battery and the design of tasks. Some of the main test battery of psycholinguistic assessments was adapted from tasks designed by Vance, Stackhouse and Wells (1995). Tests of speech output and speech input (included under this category is a task that taps the accuracy of phonological representations) were selected. They had matched items and were balanced in terms of frequency and syllable length. Further speech output tasks were also designed that used similar principles. The tests and the way they were modified for this study are described in detail in this chapter.

When interpreting results from cross-task comparison, it is necessary to understand the patterns of performance in normal development. Finding a pattern of better word than nonword repetition can only be interpreted by knowing whether this is a normal or atypical pattern in development, i.e. by comparison with a control group. A control group was thus central to the design. In order to make stringent comparisons between groups, a matched-pairs design was used, where children with speech difficulties were individually matched to control children on the basis of age, gender and nonverbal ability at the start of the study. The control group was therefore not randomly selected. In order to draw valid conclusions about normal development of speech processing and language skills, it was therefore necessary to assess how representative this control sample was of a wider population, an analysis that is described in Chapter 4.

3.2.2. Language skill

As reviewed in Chapter 1, the role of language ability in children with speech difficulties is a central area of investigation in the literature. For this reason, language skills were also assessed in some detail in this study. However, as examination of language ability was not the main theoretical motivation of the study (speech processing was), the language assessments that were used were not subject to the same principles of design and selection as the speech processing tasks. Instead, published, standardised assessments in routine use by speech and language therapists in clinical practice were selected for the test battery. These assessed receptive and expressive language skills, at both lexical and syntactic levels. These assessments were appropriate for exploring heterogeneity, and had the advantage of being norm-referenced tests. They were also considered adequate for use in multivariate analyses to explore relative contributions of speech processing and language skills to later speech and language skills.

3.2.3. Other measures

Selection of the test battery was not confined to speech and language measures. For a complete examination of the development of speech difficulties and how and why these difficulties might resolve, a range of other measures was used. These included questionnaire data on therapy received, developmental history, psychosocial development and family history. These questionnaires are described in detail in this chapter.

3.2.4. Longitudinal design

In an examination of any developmental disorder, one must keep central the fact that these disorders are developmental. In order to examine this developmental perspective, a longitudinal design was adopted, where skills were tracked at one-year intervals over a three-year period (Time 1: T1; Time 2: T2; and Time 3: T3). Additionally, as comparison with normal development is an important element of the design, longitudinal controls were used, so that normal speech processing development could be tracked and compared with atypical development. Individual difference was thus explored through both normal and atypical developmental trajectories. As discussed in the literature review, longitudinal studies are rare and longitudinal studies using a matched, longitudinal control group are even less common.

As speech processing skills were tracked over time, it was important to re-administer speech processing tasks at each time point. This led to some methodological problems, as some tests were not sensitive instruments of measurement throughout the study. This is discussed at some length in Chapter 4, and indeed, becomes a central issue in interpretation of the data. This problem was, to some extent, predicted, and also, to an extent was unavoidable, as finding speech processing tasks that are normally distributed for a control group is difficult when these skills are naturally plateauing (at the later stages of the study). Extension tasks were added at T2 and T3 in an attempt to overcome some of these difficulties. These are described in full below.

3.2.5. Rationale for the age range studied

Children were recruited at the mean age of four-and-a-half and assessed annually, at five-and-a-half and six-and-a-half. Children were selected between the ages of four and five. This ensured a more representative sample of the clinical population than selecting younger children. By the age of four, the majority of children with speech difficulties can be expected to have been referred to speech and language therapy. Younger children might not have reached clinical services, so recruitment of younger children to the study, which was through speech and language therapy services, might have resulted in a bias towards those with the most severe speech difficulties. A sample selected at a later stage would have included children with persisting difficulties, but not those whose problems might have resolved early on. As an aim of the study was to examine the factors that might contribute to a resolving or persisting profile, it was necessary to recruit at an earlier point in order to capture this resolving group. By the end of the study, one might therefore expect some of the group to have been discharged. A further aim was to examine whether these children's problems had truly resolved by this age, or whether obvious or subtle problems remained. The study was also designed to investigate the children's phonological awareness and literacy development[1]. Therefore, children of this age were examined because at or soon after the point of recruitment, they would be receiving literacy instruction.

3.2.6. Aims of the study

1. To describe the characteristics of a heterogeneous sample of children with speech difficulties over a three-year period.
   - Characteristics measured: speech and language skills; developmental history; family history; psychosocial data; intervention.

     Chapters 4 and 5
   - Detailed skills explored: development of speech output and speech input measures.

     Chapter 4
2. To explore heterogeneity in relation to speech and language measures.
   - Subgroup analysis will be used to look for patterns, based on findings in the literature, i.e. speech vs. speech and language.

     Chapter 6
3. To examine predictors of speech outcome.
   - By subgrouping children at T3 by outcome and examining whether early clinical markers can be identified.

     Chapter 7
   - Issues of pervasiveness, severity and rate of change will also be explored in relation to outcome.

[1] Phonological awareness and literacy tasks are not included in this description or subsequent analyses but are described in Stackhouse, Nathan, Goulandris et al. (unpublished).

Chapter 7

4. To assess a psycholinguistic model of disordered speech development (Stackhouse & Wells, 1997) in the light of the dataset and to extend theoretical understanding where appropriate.
   - By identifying patterns of performance across the group/dissociations amongst individuals.

     Chapter 8
   - By identifying relationships and predictors of speech development from speech processing measures.

     Chapter 8

5. To assess the relationship between speech input and speech output processing in the development of children with and without speech difficulties.
   - By examining concurrent and longitudinal relationships between speech input and speech output measures.

     Chapter 9
   - By examining whether children have difficulty with processing accent variation.

     Chapter 10

6. To assess the relationship between language and speech development of children with and without speech difficulties.
   - By examining the relationships between language measures, speech input and speech output measures.

     Chapter 9

3.3. Participants

A matched-pairs longitudinal design was adopted to investigate the speech processing and language skills of a group of children with developmental speech difficulties.

3.3.1. Children with speech difficulties

Children with speech difficulties were referred to the project by speech and language therapists in the London area. Three speech and language therapy services and one specialist speech and language centre were involved in the recruitment process. In addition, one child was identified through a nursery. Clinicians were requested to refer children on their caseload who met the following criteria:

1. Chronological age 4-5 years
2. Obvious speech difficulties but no evident physical cause (e.g. not cases with cleft lip and palate, or cerebral palsy)
3. No hearing impairment
4. No associated medical condition (e.g. epilepsy, a named syndrome)
5. No severe receptive or pragmatic language difficulties
6. Monolingual English speakers

Eighty-two children were referred of whom 47 met the following specific criteria:

1. Significant speech difficulties (more than one standard deviation below the mean) on the Edinburgh Articulation Test (E.A.T.) (Anthony, Bogle, Ingram and McIsaac, 1971)
2. Nonverbal IQ within normal limits, on two subtests of the WPSSI-R: Block Design and Picture Completion (Wechsler, 1990).
3. Nonreaders (raw score of 0) or beginning readers (four children could read 1-2 words and one child 7 words). All children scored below the 60th centile on the British Ability Scales (BAS) single word reading test (Elliott, Murray and Pearson, 1983))[2]

Twenty-four children who were referred scored within normal limits on the E.A.T., i.e. failing to meet criterion (1), and were excluded from the main study. Twelve of these

---

[2] This criterion was set in order to explore the relationship between speech difficulties and literacy skills. By selecting early readers, the reciprocal effects of literacy skill on phonological processing skill could be minimised. The criterion is not relevant within the context of this thesis, which does not focus on literacy skill.

children were subsequently followed up (Nimmo, 1998; Thurston, 1999). Three children who were referred scored above the 60th centile on BAS word reading, i.e. failed to meet criterion (3). These children participated in the study but were excluded from the main analysis. A further eight children were not included in the study for other reasons (e.g. it was found they failed to meet one of the initial criteria regarding hearing status or monolingual status). The final sample thus consisted of 47 children (31 boys and 16 girls) with specific speech difficulties whose nonverbal IQ was within the normal range. Forty-two were nonreaders and five beginning readers. Speech difficulties were more prevalent amongst males; approximately two-thirds of the speech disordered group were boys. All participants in this group were retained at follow-up at T2 and at T3.

3.3.2. Control sample

The control children were selected from the same schools or nurseries attended by the children with speech difficulties. Class teachers were asked to refer children as possible controls for individual speech cases on the bases of:

1. Same gender as child with speech problem
2. No speech or language difficulties
3. No history of speech and language problems
4. No speech and language therapy appointments
5. No known hearing impairments
6. No specific or general learning difficulties noted
7. No obvious medical condition (e.g.epilepsy)
8. Monolingual English speakers
9. Home background/mother's education

The putative controls were then tested on the Block Design and Picture Completion Tests (Wechsler, 1990) and on the British Ability Scales single word reading test (Elliott, Murray and Pearson, 1983). Each child with speech difficulties was matched to a normally developing control child on the basis of chronological age (within a six-month range), gender, and nonverbal IQ (within two points on the averaged standard score of Block Design and Picture Completion, Wechsler, 1990). In 25 of the cases, the control attended the same nursery or school as the matched child with speech difficulties in order to control for teaching environment. By the end of the study 17 pairs or 36% of the sample remained matched by school. Where school matching was not possible, the control was drawn from the same pool of nurseries/schools. All of the control children were nonreaders (i.e. raw score of 0 on the BAS, n=36) or beginning readers (i.e. reading between one and three words and scoring below 60th centile on the BAS, n=11). All controls were retained at T2 but three were no longer traceable at T3.

As a group, the children with speech difficulties did not differ from the matched group of normally developing controls on ratio of boys to girls, age, nonverbal ability, social class or level of parents' education (see Table 3.1.). Information on social class and parental education was obtained through a parental questionnaire, described in Section 3.7.2. The sample received state education from a range of Local Education Authority schools as shown in Table 3.2.

Parental permission was received for all children in the study. Ethics approval was granted from the Ethics Boards of all relevant institutions: Joint Medical Ethics Committee of The National Hospital for Neurology and Neurosurgery, Camden and Islington Local Research Ethics Committee, Barnet Research Ethics Committee, New River Health Authority Local Research Ethics Committee, the Ethics Committee of the Royal National Throat, Nose & Ear Hospital.

3.4. Tests and Materials

A summary of the tests of speech processing and language measures that were administered at three points in time is provided in Table 3.3. Testing was carried out as close to 12-month intervals as possible. There were some changes to the tests administered at each time point to avoid ceiling effects. The main change between test batteries involved adding extensions to the speech output and input tasks at T2. Tests that were at or approaching ceiling at T2 were dropped at T3: AD: same/different, AD: picture task (original version) and the word and nonword repetition tasks (original versions). For the items of all experimental speech processing tasks, see the Appendices.

Table 3.1.
Descriptive data of the Speech disordered and Control group

	Speech disordered group	Controls
	Mean (SD)	Mean (SD)
Age		
At selection (T1)	4.58 (.4)	4.63 (.39)
At T2	5.67 (.44)	5.69 (.38)
At T3	6.7 (.45)	6.72 (.41)
Nonverbal		
Block Design (ss)	10.28 (2.29)	10.68 (2.73)
Picture Completion (ss)	12.11 (2.11)	12.21 (2.22)

	%	%
Gender		
Male	70	70
Female	34	34
Parental occupation		
I	12.5	8.8
II	20	23.5
III	57.5	61.8
IV	10	5.9
V	0	0
Father's education		
No school qualifications	36.4	37.9
CSE/O'Level/GCSEs	36.4	51.7
A'levels	27.3	10.3
Further Qualifications	48.4	48.3
Mother's education		
No school qualifications	23.1	22.9
CSE/O'Level/GCSEs	59	60
A'levels	17.9	17.1
Further qualifications	37.5	45.7

Note 1: Response rates for parental questionnaires are given in Section 3.7.5.
Note 2: Parental occupation: Classified according to the Standard occupational classification, Employment Department Group, Office of Population Censuses and Surveys. 2nd Edition, Vol 2 Coding Index. London HMSO: 1995 (Great Britain Office of Population Censuses and Surveys):Categories (social class based on occupation): I Professional occupations; II Managerial & technical occupations; III Skilled occupations (N) Non-manual, (M) Manual; IV Partly skilled occupations; V Unskilled occupations. If both parents were working, the profession which rated the highest was noted.

Table 3.2.
Ranking of the 4 Local Education Authorities (LEAs) from whom the majority of participants were receiving education

Local Education Authority	Rank (out of 149)
Barnet	16
Camden	79
Enfield	88
Islington	130

Note: Figures come from the Primary School Performance Tables (1999) for England. A higher figure reflects a higher ranking school

Table 3.3.
Test Batteries at Times 1, 2 and 3

	Time 1 Age:4.60 (.39)[1]	Time 2 Age: 5.68 (.43)[1]	Time 3 Age: 6.71 (.41)[1]
Nonverbal	Block Design[2]		Block Design
	Picture Completion[2]		Picture Completion
Speech output	Word repetition	Word repetition	
	Nonword repetition	Nonword repetition	
	Articulatory naming	Articulatory naming	Articulatory naming
		LF word repetition	LF word repetition
		LF nonword repetition	LF nonword repetition
Speech input	AD: picture	AD: picture	AD: picture 2
	AD: ABX	AD: ABX	AD: ABX
	AD: same/different	AD: same/different	
Expressive language	Naming	Naming	Naming
	Bus Story	Bus Story	Bus Story
	RAPT	RAPT	RAPT
Receptive language	BPVS	BPVS	BPVS
	TROG	TROG	TROG

[1]age in decimals (standard deviations in parentheses)

[2] These tests were part of the screening process, but versions of them were also re-administered at T3.

Key: RAPT: Renfrew Action Picture Test; BPVS: British Picture Vocabulary Scale; TROG: Test for Reception of Grammar; LF: Low Frequency; AD: Auditory Discrimination

3.4.1. Nonverbal tests: Wechsler Preschool and Primary Scale of Intelligence – Revised (WPSSI-R; Wechsler, 1990) and Wechsler Intelligence Scale for children – 3rd Edition (WISC-III^{UK}; Wechsler, 1992)

Nonverbal performance was measured as a selection screen at T1 (Wechsler, 1990). A second version of these two tests for older children was administered at T3 (Wechsler, 1992) in order to monitor nonverbal development.

For Block design, the child is required to copy some designs using coloured blocks. The designs are presented using 3-D blocks for the child to copy and designs are also presented in a booklet. For Picture completion, incomplete pictures are presented. The child must show the examiner what is missing from the picture.

3.4.2. Receptive language tests

3.4.2.*1*. Test for the Reception of Grammar –TROG (Bishop, 1983)

This test assesses a child's understanding of syntactic structures of increasing difficulty. The child is asked to point to one of four pictures in response to a spoken stimulus. This test will be referred to as TROG.

3.4.2.*2*. British Picture Vocabulary Scale - BPVS (Dunn, Dunn, Whetton & Pintilie, 1982)

This test measures receptive vocabulary. The child is asked to listen to a spoken stimulus and point to the corresponding picture from a choice of four. This test will be referred to as BPVS.

3.4.3. Expressive language tests

3.4.3.*1*. Renfrew Action Picture Test - RAPT (Renfrew, 1988)

The child is shown 10 pictures and asked a question about each one. Two scores are calculated: an information score and a grammar score. This test will be referred to as RAPT.

3.4.3.*2*. The Renfrew Bus Story (Renfrew, 1995)

The child is told a short story with accompanying pictures about a naughty bus and requested to retell the story to the examiner using the pictures. The test is scored for both information recalled and mean length of utterance (MLU). This test will be referred to as the Bus Story.

3.4.3.3. Naming (after Snowling, van Wagtendonk and Stafford, 1988)

The child's word finding abilities are tested by requesting the child to name a series of 20 pictures, e.g. BALLERINA, STETHOSCOPE. Two scoring systems were adopted: a) accuracy of retrieving the lexical item even if speech errors are made, b) accuracy of the production of the name of the item. If the child failed to name the picture, a forced choice condition was administered, when the child had to guess from three oral stimuli, e.g. for the picture of BALLERINA: GYMNAST, ICE-SKATER, BALLERINA; for the picture of STETHOSCOPE: STETHOSCOPE, SYRINGE, TELESCOPE. This was not scored but was considered when the task was scored for articulatory accuracy (see section 3.4.6.1. iii).

3.4.4. Speech processing tasks

Some of the speech processing tasks described below are reduced versions of tasks devised by Vance, Stackhouse and Wells (1995) and Vance (2001). These tasks were explicitly designed to examine normal speech processing development, according to the model developed by Stackhouse and Wells (1997). Other tasks were designed for this study and were included principally to avoid predicted ceiling effects at later testing phases, especially in the control group.

Reduced versions of the Vance et al. tests were used in this study due to the large test battery and time limitations. The children's attention span in completing this large test battery was also considered. Reduced versions of four tasks were constructed: word repetition, nonword repetition, auditory discrimination: picture task, auditory discrimination: ABX task. A fifth task, the auditory discrimination: same/different task designed by Bridgeman and Snowling (1988) which had also been administered by Vance et al., was similarly reduced in size.

The four experimental tasks were all derived from the same set of stimuli, with nonwords derived as appropriate. Each stimuli list consisted of three sets (Set 1: 1-syllable words/nonwords; set 2: 2-syllable words/nonwords; set 3: 3 / 4-syllable words/nonwords). The two repetition tasks and the auditory discrimination: picture task and auditory discrimination: ABX task were reduced from 60 items to 24 items. The auditory discrimination: ABX task was further reduced to 12 items at T1. The auditory discrimination: same/different task was reduced from 60 to 20 items. Below are details of these reduced version tests (3.4.4.) followed by a description of how the items were selected following an item analysis (3.4.5.).

All these tasks were split into two lists, list A and list B. List A and list B were administered in separate sessions.

3.4.4.*1*. Speech output tasks

3.4.4.*1*.i. Word repetition

Each child was asked to repeat 24 single words (lists A and B). Words were assigned randomly to each list. Each list comprised four one-syllable words (e.g. BRUSH), four two-syllable words (e.g. TRACTOR), four three- and four-syllable words (e.g. ELEPHANT). The lists were presented in random order. Three practice items were presented before testing began. Corrective feedback was given if the child failed to repeat the word, but only general encouragement was given during the test. Stimuli were presented via a tape recording but one 'live' repetition was allowed if the child failed to respond to a stimulus or they requested a repetition. All responses were transcribed in phonetic script at the time and were recorded for later reliability checks. The percentage of consonants correct was calculated, a procedure recommended by Shriberg and Kwiatkowski (1982) who used this scoring system as a measure of severity. It has also been used in similar studies (e.g. Bishop & Adams, 1990; Bird, Bishop & Freeman, 1995; Larrivee & Catts, 1999) as a measure of speech output. It is likely to be a more sensitive measure than looking at whole word accuracy.

3.4.4.*1*.ii. Nonword repetition

Twenty-four nonwords (lists A and B) were derived from the words in the word repetition task by changing the vowels (the consonants remained the same). In each list there were four one-syllable nonwords (e.g. /brɪʃ/), four two-syllable nonwords (e.g. /trɛktɪ/), four three- and four-syllable nonwords (e.g. /ælɪfɒnt/). The items were randomised as described under word repetition. The lists were presented in an order that ensured that the words from which the nonwords were derived would be presented at a different session (i.e. list A did not contain any nonwords that had been derived from the words in that list).

The task was presented to the child using a toy monkey who said 'made up, monkey words'. The child was told that s/he would not know these words and was asked to say each word like the monkey had said it. There were three practice items. Corrective feedback was given during the practice items. Lexicalisations (i.e. producing a similar sounding word rather than the nonword) were discouraged. The test items were presented as for the word repetition, with all responses being tape recorded and transcribed phonetically. The percentage of consonants correct was calculated.

3.4.4.2. Speech input tasks

3.4.4.2.i. Auditory discrimination: picture task (after Locke, 1980)

This task was based on Locke's (1980) 'speech production-perception task', reviewed in Chapter 1. The task consisted of 24 pictures, in two parallel forms (A and B). The child was asked to look at the picture and decide if a pre-recorded stimulus was the name of that picture (e.g. picture of a PLATE presented and the child hears "PATE", or "PLATE"). Nonwords were derived by changing the consonants by voicing, place or manner of articulation; some changes also involved metathesis.

Two spoken stimuli were presented with each picture for half the items and three spoken stimuli for the other half of the items (their order randomised). The third presentation, which was not scored, could be either correct or incorrect (i.e. PATE or PLATE) and was introduced to reduce the possibility of the child predicting the next presentation.

There were two practice items. A toy monkey was used to explain the task. The child was told that the monkey is sometimes a "clever monkey" and sometimes a "silly monkey". When the stimulus was produced correctly on the tape recording, the child was expected to say that the monkey had been right or clever and when the stimulus was said incorrectly, the child was expected to say that the monkey had been wrong or silly.

This task will be referred to as the AD: picture task.

3.4.4.2.ii. Auditory discrimination: ABX task

This task consisted of 12 pairs of nonwords (in two parallel forms, list A and B). As a pilot study and the results reported by Vance et al. revealed this to be a difficult task for young children, a short version was used at T1, with the full version being brought on line at T2.

The task was introduced to the child, using six practice items for the short version, and four practice items for the longer version. Two monkeys (distinguished by their appearance) were introduced to the child: "these monkeys talk: this monkey is going to say something, then this monkey is going to say something else, something different. This monkey says /səʊf/ (point to first monkey), this monkey says /təʊf/ (point to second monkey). Which one said /səʊf/?" The child was expected to point to the first monkey. Corrective feedback was given as necessary. If the child responded correctly this was reinforced by saying "yes, he said /səʊf/" or, if the child failed to respond, the instructions were repeated. If he still failed to respond, the examiner could show him the response required by pointing to the first monkey and saying, "he said /səʊf/". If the child pointed to the wrong monkey, the examiner could say, "let's listen again", repeat the instructions and then point to the first monkey again, saying, "he said /səʊf/, didn't he". The next practice item was presented in the same way with feedback as necessary. For subsequent practice items the cue phrases began to be phased out by just saying the non-word stimulus as each monkey is pointed to, and then asking "who said X?".

If the child failed 4/6 practice items on the reduced version of 12, the test was discontinued.

This task will be referred to as the AD: ABX task.

3.4.4.2.iii. Auditory discrimination: same/different task (from Bridgeman and Snowling, 1988)

This auditory discrimination task comprised 10 pairs of words and 10 pairs of nonwords, equally divided into two lists (A and B) with nonwords presented first. The pairs of words differed either by a feature change (e.g. /s/ - /t/, as in LOSS/LOT or VOS/VOT) or a sequence change (e.g. /st/ - /ts/, as in LOST/LOTS or VOST/VOTS). The child was asked to say if a pair of stimuli (words or nonwords) spoken by the tester sounded the same or different. The task was modelled using the child's name to ensure the concepts of same/different were understood. Three additional practice items were also administered during which corrective feedback was given.

If the child got fewer than three practice items correct, the test was discontinued. The task items were presented with general encouragement but no feedback was given.

This task will be referred to as the AD: same/different task.

3.4.5. Item analysis

Selection of items for these reduced versions was informed by an extensive item analysis of the data from Vance et al. (1995) and Vance (2001) carried out by the author[3]. Item analysis was also conducted on data from a group of 10 children with speech and language difficulties, all attending Language Units (data collected by Vance, 2001) in order to aid selection of items that discriminated well between populations.

A difficulty index was calculated as conducted by Anthony et al. for the Edinburgh Articulation Test (1971) and recommended by Anastasi (1976). This index was the percentage of children getting each item correct according to age group or according to membership of the normally developing or speech disordered group. This index showed the degree of difficulty of individual items depending on age or group status.

The final selection of items was motivated by the following points:

1. The balance between sets of syllables was maintained. It was considered important to maintain the original range of syllable length. This was seen as more important than increasing the discrimination of items between groups (see point 4), which would have resulted in the selection of longer items which created more errors, particularly for the language impaired group. This finding was considered at T2 when a new repetition task was devised which used longer word and nonword stimuli (up to five syllables) in order to create more challenging items for both groups.

[3] Scoring for the item analysis was carried out using criteria outlined by Vance et al. (1995). For speech output tasks, scoring was by whole word accuracy. For input tasks, scoring was by total number correct. This scoring system for speech output tasks is different from that used in the main analyses conducted which is reported in full in Chapters 4, 6-9.

2. The balance of items which underwent the metathetic/feature manipulation was retained (i.e. half of the two to four syllable stimuli) in the AD: picture task.
3. Items were chosen that showed good discrimination between ages, i.e. a good developmental pattern. If there was a high degree of accuracy on an item, it was a candidate for exclusion. This was attempted across different tasks that used the same items, though due to good levels of performance on the AD: picture task, it was not possible to select items that showed similar levels of difficulty across all tasks.
4. Items were chosen that showed good discrimination between normally developing children and children with language difficulties, e.g. TRACTOR and CATERPILLAR.
5. Items selected should have some degree of homogeneity.
6. Phonetic characteristics were considered. An attempt was made to include a range of fricatives and clusters.
1. Where possible, items that showed a word/nonword discrepancy were included (a word-nonword discrepancy had already been observed by Vance et al. (1995) and Vance (2001), e.g. SLIPPER and /slɔpə/).
8. Some items were dropped as it was predicted they would be difficult to score if a participant had a London accent. For example, FEATHER and THUMB were dropped as the realisations of these words as [fɛvə] and [fʌm] are acceptable in a London accent and so the targeted features /ð/ and /θ/ are not being tapped.

3.4.6. Further speech processing tasks

In addition to these tasks, further speech processing measures were devised or adapted. An articulatory naming score was derived from the Naming task (described above) in order to obtain a measure of spontaneous naming as opposed to repetition. Further repetition tasks were devised for administration at T2, in addition to the above repetition tasks. At T3, these became the sole repetition tasks administered. Another AD: picture task was devised for use at T3 to replace the original one, which was reaching ceiling at T3. These tasks are described below and items are listed in the Appendix.

3.4.6.*1*. Further speech output tasks

3.4.6.*1*.i. Low Frequency word repetition.

At T2, a more challenging word repetition task was introduced in order to extend the word repetition task (which was then phased out at T3). This consisted of 20 low frequency words of 1 to 5 syllables in length, e.g. SQUEAK, DRUMMER, GORILLA, LIBRARIAN, ELECTRICITY. The procedure was similar to the other repetition tasks. Percentage of consonants correct was calculated. This will be referred to as the LF word repetition task.

3.4.6.*1*.ii. Low Frequency nonword repetition.

Twenty matched nonwords (created from the low frequency words of the LF word repetition task) were presented at T2 and T3, e.g. /skwuk/, /dɹɒmɪ/, /gæɹɒlu/, /laʊbɹəʊɹaʊn/, /ɒlɪktɹæsʊta/. The original nonword repetition task was phased out at T3. The task followed a similar procedure to the other repetition tasks. Percentage of consonants correct was calculated. This will be referred to as the LF nonword repetition task.

3.4.6.*1*.iii. Articulatory naming

The child's naming accuracy was assessed by calculating the percentage of consonants correctly produced (see Expressive Language tasks in Section 3.4.3.*3*. above for a description of this task). This score was derived from the number of consonants correctly produced either by naming a picture or, if the child did not name the picture spontaneously, by repeating one of three forced choice items (if the child responded with the correct lexical item in the forced-choice response paradigm).

3.4.6.*2*. A further speech input task

Auditory discrimination: picture task II (adapted from Constable, Stackhouse & Wells, 1997)

This task was included at T3 only where the original AD: picture task was dropped due to ceiling effects. The task comprised 10 words (five three-syllable words and five four-syllable words) and 10 closely matched nonwords. Five nonwords were derived by modifying the onset consonant of the third or final syllable to imitate a perseverative error (e.g. ESCALATOR - /ˈeskəleikə/) and five by transposing two onset consonants (e.g. ELEPHANT - /ˈefilənt/). Presentation of the items replicated the procedure of the AD: picture task.

This task will be referred to as the AD: picture task II.

3.4.7. Transformation of speech input scores

Scores of *d'* (d prime), an unbiased measure of sensitivity, were used in analyses for all the speech input tasks as these tasks involved forced choice responses, and therefore could be subject to certain biases. A *d'* score was calculated based on each participant's hits and false-alarms. These scores were calculated, as described in Macmillan and Creelman (1991), for each of the three tasks. When a participant scored 0% or 100%, the total possible responses for each type of response was doubled and one error assumed (S.Rosen, personal communication, April 2000) before *d'* was calculated, in order to avoid infinite *d'* values (see also Macmillan and Creelman, 1991, p.10).

For the AD: picture task, the hit rate was defined as the proportion of words to which the participant correctly responded 'yes', and the false-alarm rate was the proportion of nonwords incorrectly identified as words (i.e. also responding 'yes').

For the AD: same/different task, the hit rate was the proportion of different pairs to which the participant correctly responded 'different', and the false-alarm rate was the proportion of same pairs which were incorrectly identified as 'different' pairs.

For the AD: ABX task, the hit rate was the proportion of responses where the participants responded that X (the third stimulus) matched the first stimulus (monkey 1) and the false-alarm rate was the proportion of responses where X was incorrectly identified as matching the first stimulus.

3.5. Procedure for test battery

The procedure for administering the test battery was similar at each testing phase (T1 took place between January 1996 and January 1997; T2 took place between April and

December 1997 and T3 took place between April and December 1998). The author carried out all assessments.

Testing mainly took place in a quiet room at the child's nursery or school. On some occasions, the assessments were carried out in the child's home. Tests were administered over several sessions on two or more days, depending on individual timetables and each child's ability to concentrate. The tests were pseudo-randomised into four different orders of presentation to avoid practice or fatigue effects in the same session. Participants were randomly allocated to receive one of these orders. An average of four to five sessions per child was needed to complete the battery. Auditory stimuli for the word and nonword repetition and AD: picture tasks were pre-recorded on audio tape using a Marantz CP430 and Marantz microphone EM-8 and played back on a Phillips AQ6350 cassette recorder. The AD: same/different task and the AD: ABX task were presented in a live voice condition, following a pilot study which had shown this to be more appropriate for these young children. For these tests, the examiner's mouth was obscured, to prevent lip-reading.

Children's responses on all speech output tasks were audio recorded onto a Sony Walkman Professional WM-D6C with an ECM-909A microphone. The repetition tasks were transcribed live in phonetic script and checked later using the audio recording. To check reliability, a speech and language therapist transcribed 10% of the word and nonword repetition tasks at each testing point. 88.37% agreement was found, collapsing across tests and times. This is a comparable level of reliability to similar studies that report levels of agreement. Williams and Chiat (1993) using a "random sample of test" (an unspecified number) on the Edinburgh Articulation Test (E.A.T., Anthony et al., 1971), one of their preliminary measures, found 83% agreement between raters. Bradford and Dodd (1996) using 10% of samples from a connected speech sample and word test (i.e. measures that they were using to assign subjects to group) found approximately 80% agreement. Dollaghan, Biber & Campbell (1995) randomly selected 6 out of 30 tapes of speech stimulus and obtained 86.7% agreement.

3.6. Feedback

When the child was receiving or continuing to receive speech and language therapy, results of standardised assessments were sent to the speech and language therapist. Oral feedback was given to parents, speech and language therapists and teachers when requested.

3.7. Questionnaire data

Supplementary information was collected through questionnaire data. Two questionnaires were completed by parents relating to their child's development (Developmental questionnaire) and to family history of speech, language or literacy problems (Family history questionnaire) after completion of T3. A questionnaire was completed by teachers that elicited information about psychosocial status at T3 (Goodman's Strengths and Difficulties Questionnaire (SDQ), 1997); a therapy questionnaire recorded information about the type and amount of therapy received during the course of the study (Therapy questionnaire). Each questionnaire is summarised below. The developmental, family and therapy questionnaires are appended.

3.7.1. Developmental questionnaire

Following T3, when the children were aged 6.7, a questionnaire was sent out to all parents of the children in the study to gather information about their children's development. Information on literacy development was also collected but is not described or reported here.

The questionnaire covered the following areas:

Birth and general health details

- child's birth position in relation to siblings
- whether child was born prematurely
- complications associated with the birth
- feeding difficulties
- allergies/fits/asthma/frequent coughs and colds/ear infections/catarrh

Physical development

- age child started to walk
- parental concern over child's physical development
- help/treatment sought/received
- current problems

Hearing

- parental concern over child's hearing
- help/treatment sought/received
- current problems

Speech and language

- age child began talking
- parental concern over child's speech or language development
- help/treatment sought/received
- current problems

Vision

- parental concern over child's vision
- help/treatment sought/received
- current problems

Additional information

Handedness (researcher observation)

3.7.2. Family questionnaire

Following T3, when the children were aged 6.7, a questionnaire was sent out to all parents of the children in the study. Both parents were requested to fill in a questionnaire. Results from sections 1 and 2 are summarised in Table 3.1 of this chapter (Participants).

The questionnaire covered the following areas:

1. **Mother's/father's qualifications**
2. **Mother's/father's occupation**
3. **Family history of reading/spelling difficulties**

Parent of child in the study, the parent's siblings, parents and grandparents

4. Family history of speech difficulties

- Whether the parent had ever attended a speech therapy clinic or had ever had hearing loss
- Family history of speech difficulties of parent of child in the study, the parent's siblings, parents and grandparents
- Information was collected through telephone interviews on whether siblings of children in the study were experiencing speech, language and/or literacy problems.

3.7.3. Therapy questionnaire

Information was collected from each child's speech and language therapist at three points:

- At T1, covering the period when the child was first referred to speech and language therapy up until the T1 assessments were carried out
- From T1 up until the T2 assessments
- From T2 up until the T3 assessments.

The questionnaire covered the following areas:

1. Age of referral to speech and language therapy
2. Number of individual sessions during the time period
3. Number of group sessions during the time period
4. Average length of individual and group sessions during the time period
5. Type of therapy (not mutually exclusive categories): phonological /oral motor skills/ articulatory /phonological awareness /expressive language /receptive language /play skills /listening skills /social skills /parent workshop /parent-child interaction /other
6. Therapy setting: clinic /school /language unit /hospital /combination of settings/ specialist centre
7. Frequency of liaison: yearly /termly/occasionally/none /ongoing
8. Management (not mutually exclusive categories): regular for therapy /on review /on waiting list /planned discharge /discharged
9. Involvement of other agencies (e.g. educational psychologist).

3.7.4. Psychosocial information

During T3, teachers also completed Goodman's (1997) Strengths and difficulties Questionnaire (SDQ). This provided information about the children's emotional status, conduct, hyperactivity, peer relations and prosocial behaviour. The teacher was asked to tick whether they agreed with statements such as: "*Often unhappy, downhearted or tearful*" (Emotional scale); "*Often lies or cheats*" (Conduct scale); "*Restless, overactive, cannot stay still for long*" (Hyperactivity scale); "*Rather solitary, tends to play alone*" (Peer relations scale); "*Considerate of other people's feelings*" (prosocial scale).

3.7.5. Questionnaire response rates

Developmental questionnaire: 80.9% of forms were returned. The response was slightly higher for the speech disordered group (87.2%, n = 41) than for the control group (74.5%, n = 35) (this includes three no responses from children whom it was not possible to retrace at T3).

Family history questionnaire: 80% of questionnaires were returned from mothers (85% of speech disordered group; 74% of controls) and 66% of questionnaires from fathers (70.2% of speech disordered group; 61.7% of controls). Fewer responses were received from the fathers of the children in the study. This was attributable to some fathers not living with their child.

Strengths and Difficulties questionnaire: 98.9% of questionnaires were completed on the children who were assessed at T3.

Therapy questionnaire: 97.8% of T1 questionnaires were returned; 95.7% of T1-T2 questionnaires were returned and 89% of T2-T3 questionnaires were returned. (Note: 1 child was not receiving speech and language therapy at T1.)

3.8. Summary

This chapter has outlined the methodology of the longitudinal study, describing the rationale for task selection, test design, participant selection and procedure. The following chapter explores some methodological issues in terms of the representativeness of the control sample and task reliability. Chapter 4 and Chapter 5 focus on an exploration of group differences in the test battery.

Chapter 4
Development of speech processing and language skills over time

4.1. Introduction

The aim of this chapter is to explore both normal and atypical speech and language development by examination and comparison of the two groups: the children identified as having a speech difficulty at age four and the matched control group of normally developing children. The core test battery included measures that have been found to be impaired in children with speech difficulties: measures of speech output (e.g. Shriberg et al., 1994), of language (e.g. Bishop & Adams, 1990; Lewis & Freebairn, 1992; Shriberg et al., 1999) and of speech input (Bird & Bishop, 1992). According to this research, there is a degree of co-occurrence of language and/or speech input deficits with speech disorder. However, speech disorder is neither unitary nor static, but heterogeneous and changing. It is still unclear how these co-occurring deficits develop over time. Similarly, their causal or interactive relationship with the speech disorder, especially the relationship between speech input and output processing, also remains unclear. In order to capture the changing aspect of the disorder over time, it is important to track the developmental trajectory of these speech processing and language skills. The best way of capturing and describing these changes is to measure these skills longitudinally in children with speech disorders. In order to interpret such changes, we must also extend our understanding of the normal pattern of development of some of these skills. By tracking normal development one can attempt to examine how speech and language skills continue to develop in middle childhood and to pinpoint when these skills have become established.

Tracking and comparing normal and disordered development raises a number of issues of methodology and task design which will also be addressed in this chapter. Whilst an understanding of the development of speech and language skills requires the use of two longitudinal samples, a speech disordered and a control sample, interpretation of normative performance is somewhat restricted by the matched-pairs design. The control group was matched to the clinical group by age, nonverbal ability and gender in order that any differences found between the two groups could be attributed to differences associated with the presenting speech difficulty rather than other non-related skills. Thus the control group was not a randomly selected group. Notably, it was not balanced according to gender: there was a high proportion of males, because of the higher proportion of males in the speech disordered group, itself a reflection of the higher prevalence rates of speech and language difficulties in boys (Shriberg et al., 1999). Nonetheless, the control sample selected had a range of nonverbal skills within the normal distribution and the children came from a range of socio-economic backgrounds. There are thus some grounds for considering this control group as a fairly representative sample. In order to examine the control group's performance further, this group will be compared in two ways. As some tasks were standardised, the control group can be compared to the standardisation sample of these tasks. Second, a study carried out by Broadbent (2000) used some of the experimental tasks on a different sample of children and comparison is made between the two samples.

A second methodological issue in examining aspects of speech and language development is that of the reliability of the measures. Some issues of reliability arise from the longitudinal study where, in order to examine change, the same tasks are repeated over time. It is difficult to measure a single variable at different ages because tasks can be prone to floor and ceiling effects. At a younger age, there may be floor effects, if a more complex or later developing skill is measured. For older children, ceiling effects are possible, if the skill has become well established. If the same measure is used at different ages, it may not be measuring the same thing (Bergman, Eklund & Magnusson, 1991) because, for example, different strategies are employed at different ages or other skills start to influence performance.

The difficulties of designing adequate speech input measures have also been acknowledged (Locke, 1980; Vihman 1996). For example, a task that is designed to measure auditory discrimination but has a high memory load, may not be measuring auditory discrimination at all if a child is struggling with the memory component. For young children, a demanding or long task may be measuring attention skills or have excessive conceptual demands (Locke, 1980). The speech input tasks used in this study required forced-choice responses, making it possible that children might guess if they were unsure or being inattentive. Second, ceiling effects are quite common with this sort of task: once the skill being measured has been mastered, a child is likely to get high scores, resulting in a poor distribution of data. For these reasons it is possible that the tasks might vary in their reliability in terms of assessing what they purported to assess and in their sensitivity to pick up group differences.

The issues to be explored in this chapter can be summarised by the following questions:

1. How representative is the control group of normally developing children?
2. How reliable are the experimental tasks?
3. What is the developmental pattern of performance of the two groups on the measures of speech output, speech input, language and nonverbal skills between four and six years?
4. Do children with speech difficulties perform differently to matched normally developing controls on measures of speech output, speech input, language and nonverbal skills at ages four, five and six?

4.2. Results

4.2.1. Descriptive statistics

Means and SDs of the speech processing and language measures by group membership are reported in Tables 4.1 and 4.3. Table 4.2 reports *d'* scores for the speech input tasks (calculated as described in 3.4.7. of Chapter 3) which were used in subsequent analyses. SDs show the speech disordered group to have a wide range of variance on speech output tasks compared to the control group. On speech input and language tasks, the SDs are broadly similar across groups.

Table 4.1.
Mean performance and SDs of the Speech disordered group and Controls on tests of speech processing at T1, T2 and T3

	Speech disordered group	Controls
T1		
Word repetition pcc	49.30 (17.09)	92.82 (5.48)
Nonword repetition pcc	48.27 (15.73)	90.39 (5.67)
Articulatory naming pcc	50.92 (17.98)	88.90 (9.81)
AD: picture (Max=48)	39.09 (6.23)	42.94 (4.34)
AD: ABX (Max=12)	6.93 (2.18)	7.87 (2.01)
AD: S/D (Max=20)	14.0 (3.9)	15.9 (3.6)
T2		
Word repetition pcc	79.03 (20.0)	98.40 (2.32)
Nonword repetition pcc	74.61 (19.67)	95.41 (5.10)
Articulatory naming pcc	73.92 (17.39)	94.28 (3.91)
LF word repetition pcc	65.14 (21.05)	90.86 (6.38)
LF nonword repetition pcc	58.94 (17.93)	83.17 (8.66)
AD: picture (Max=48)	44.21 (3.62)	45.59 (3.83)
AD: ABX (Max=24)	15.98 (3.81)	17.93 (3.5)
AD: S/D (Max=20)	17.02 (2.98)	18.11 (2.38)
T3		
Articulatory naming pcc	83.47 (10.96)	93.94 (4.88)
LF word repetition pcc	80.51 (13.19)	92.51 (5.77)
LF nonword repetition pcc	69.32 (14.60)	85.66 (8.69)
AD: picture 2 (Max=20)	18.96 (1.0)	19.02 (1.11)
AD: ABX (Max=24)	18.43 (3.02)	20.45 (2.46)

Note 1: SDs in parentheses
Note 2: pcc = percentage of consonants correct
Note 3: AD: picture, AD: ABX and AD: same/different raw scores are reported here (for *d'* see Table 4.2.)

Table 4.2.
Mean *d'* performance and SDs of the Speech disordered group and Controls on tests of speech input

	Speech disordered group	Controls
T1		
AD: picture	2.2 (.99)	2.8 (.86)
AD: ABX	.75 (1.16)	1.14 (1.19)
AD: S/D	2.34 (1.44)	3.09 (1.63)
T2		
AD: picture	3.01 (.92)	3.48 (.75)
AD: ABX	1.4 (1.11)	1.88 (1.05)
AD: S/D	2.9 (.98)	3.24 (.91)
T3		
AD: picture 2	2.9 (.38)	2.92 (.42)
AD: ABX	2.01 (.81)	2.53 (.66)

Note: SDs in parentheses

Table 4.3.
Mean performance and SDs of the Speech disordered group and Controls on language and nonverbal measures

	Speech disordered group	Controls
T1		
Bus Story (information score)	16.64 (7.66)	20.89 (7.23)
Bus Story (MLU)	6.41 (2.14)	9 (2.28)
RAPT (information score)	28.13 (4.72)	30.50 (3.73)
RAPT (grammar score)	15.64 (6.04)	22.79 (4.42)
Naming	6.19 (2.42)	8.45 (3.08)
BPVS	34.26 (10.30)	43.53 (13.08)
TROG (number of items)	45.09 (12.56)	51.11 (14.78)
T2		
Bus Story (information score)	22.61 (7.62)	27.83 (7.12)
Bus Story (MLU)	8.94 (2.50)	10.45 (2.37)
RAPT (information score)	32.46 (3.26)	33.40 (3.25)
RAPT (grammar score)	22.04 (5.17)	26.17 (3.83)
Naming	8.74 (2.68)	11.32 (3.13)
BPVS	48.04 (11.84)	55.52 (13.74)
TROG (number of items)	58.0 (10.33)	63.22 (9.46)
T3		
Bus Story (information score)	27.47 (7.50)	31.42 (6.63)
Bus Story (MLU)	10.75 (2.33)	11.78 (2.38)
RAPT (information score)	34.36 (2.84)	34.88 (3.26)
RAPT (grammar score)	24.23 (4.43)	26.77 (3.63)
Naming	10.74 (3.19)	12.98 (3.0)
BPVS	57.04 (10.51)	68.68 (13.07)
TROG (number of items)	66.28 (6.78)	69.86 (6.16)
Block design (WISC-III^{UK})[1]	15.36 (9.75)	18.59 (9.54)
Picture Completion (WISC-III^{UK})[1]	10.96 (3.15)	13 (3.35)

Note: SDs in parentheses
[1] Nonverbal standard score composite: Speech disordered: 8.8 (2.3); Controls: 10.0 (2.2)

4.2.2. Evaluation of test battery through analysis of reliability

In order to assess how reliable the experimental assessments were, and so how confident one could be that the scores obtained reflected underlying ability, tests of reliability were carried out. As Kline (2000) reports that there is a negligible difference between conducting split-half reliability and alpha co-efficients, split-half reliability was calculated, with the Spearman-Brown formula to correct for the underestimation of reliability when using a split-half procedure (see Kline, 2000, p. 13).

Table 4.4 shows split-half reliability co-efficients for the speech output and speech input tasks, calculated for the total sample, and also by group (Speech disordered, Control). Reliability co-efficients are also reported over testing phases and at individual testing phases. Reliability was found to vary according to group and testing phase. Kline (2000) reports .7 as a minimum level of reliability and .9 as a high level of reliability. Mitrushina, Boone & D'Elia (1999) suggest .6 as a minimum level of reliability.

4.2.2.*1*. Speech output tasks

Reliability co-efficients were calculated for the word and nonword repetition tasks. Reliability co-efficients were not calculated for the articulatory naming task because the number of items a child articulated was dependent on the number of items that the child was *able* to name. This task was originally designed to assess lexical naming and not articulatory naming. If the child did not know the picture, or did not name it correctly following the forced-choice condition, the child would not have produced the item and therefore no attempt was scored. The total number of items articulated therefore varied from child to child making it difficult to conduct a split-half reliability as, especially at T1, a child may have articulated very few items in the first or second half of the list[4]. It should be noted that given this variation between children in the number of targets articulated, that this may not have been an entirely reliable assessment of speech output.

---

[4] This problem was apparent to a much smaller extent on the repetition tasks, where a child, on occasion, may have failed to produce a response. Percentage of consonants correct was then calculated on the total number of consonants of those words that were attempted.

Very high reliability is shown for the repetition tasks when groups are collapsed, and this holds over the three testing phases. When examined by group, it is apparent that the reliability of the speech disordered group's scores is greater than that of the controls. The control group shows less reliable scores for nonword repetition at T1, and for word, nonword and LF nonword repetition at T1 and T2. High reliability obtained by the speech disordered group on the repetition tasks is likely to be due to the relative difficulty of these tasks to children with speech difficulties, resulting in a more uniformly poor performance compared to normally developing children.

Table 4.4.
Reliability Co-efficients for the speech output and speech input tasks
(The Spearman-Brown split half reliability co-efficient is reported)

Test	Speech disordered group	Control group	Both groups
Over testing phases			
Word repetition pcc (T1-T2)	.97	.83	.98
Nonword repetition pcc (T1-T2)	.97	.63	.97
LF word repetition pcc (T2-T3)	.97	.80	.97
LF nonword repetition pcc (T2-T3)	.94	.76	.94
AD: picture (T1-T2)	.75	.82	.78
AD: ABX (T1-T3)	.66	.72	.72
AD: S/D (T1-T2)	.72	.70	.72
T1			
Word repetition pcc	.91	.81	.97
Nonword repetition pcc	.89	.58	.96
AD: picture	.73	.71	.74
AD: ABX	-.25	.43	.20
AD: S/D	.83	.71	.78
T2			
Word repetition pcc	.96	.08	.96
Nonword repetition pcc	.94	.51	.95
LF word repetition pcc	.97	.79	.97
LF nonword repetition pcc	.93	.54	.92
AD: picture	.64	.76	.72
AD: ABX	.70	.71	.73
AD: S/D	.27	.42	.36
T3			
LF word repetition pcc	.90	.74	.90
LF nonword repetition pcc	.89	.73	.90
AD: picture 2	.43	.05	.23
AD: ABX	.65	.51	.63

4.2.2.2. Speech input tasks

Mixed reliability was obtained on the speech input tasks and is related, in part, to the occurrence of guessing - a source of unreliability (Kline, 2000). The reliability of the AD: ABX task varied over time, with very poor reliability at T1, where many children were performing at a chance level, improved reliability at T2, and a slight drop at T3. The opposite pattern was observed for the AD: picture task, with reliability being adequate at T1 and T2, but low reliability obtained at T3, for the extension task.

4.2.2.3. Standardised assessments

4.2.2.3.i. Reliability of standardised assessments

Table 4.5 reproduces the reliability co-efficients of those standardised assessments where such data was available, as reported in the published manuals of the WPSSI-R, WISC III^{UK}, BPVS and TROG. Overall, this shows that satisfactory levels of reliability were obtained on the standardised assessments compared to the experimental speech output and speech input tasks (except for those tasks where reliability was poor at certain ages, as reported above). These levels of reliability were comparable to some of the experimental tasks, except that the reliability was more consistent over time.

Table 4.5.
Reliability Co-efficients of standardised assessments as reported in test manuals (Only relevant ages are shown)

Test	Split-half reliability co-efficient						
	Age band						
	4	4.6	5				
WPSSI-R Block Design	.87	.88	.86				
WPSSI-R Picture Completion	.87	.93	.86				
	Age band						
	6	7					
WISC III^{UK} Block Design	.82	.77					
WISC III^{UK} Picture Completion	.77	.84					
	Age band						
	4-4;11	5-5;11	6-6;11				
BPVS	.84	.91	.90				
	Age band						
	4-4;02	4;03-4;05	4;06-4;08	4;09-4;11	5;0-5;05	5;06-5;11	6;0-6;11
TROG	.78	.85	.81	.80	.74	.74	.76

Note: Reliability co-efficients were reported to have been corrected using the Spearman-Brown formula, except in the case of TROG where this correction was not reported

4.2.2.3.ii. Standardised scores

Comparison between the control group's scores at T1 and the standardisation samples of each test found similar mean scores, as illustrated in Table 4.6. On the BPVS, the control group scored a standard mean score of 101; and on the TROG, the average percentile rank of 54.44 showed the controls performing at a similar level to the standardisation sample. Norms available on the Renfrew tests and on the Naming task were also broadly in line with the control group's performance.

Table 4.6.
Comparison of Control group's scores at T1 with standardisation samples

Test	Control group at T1 (mean age 4.63)				
BPVS standard score	101.32 (14.35)				
TROG percentile rank	54.44 (30.64)				
		Published norms for 4-year-olds		Published norms for 5-year-olds	
Bus Story information score	20.89 (7.23)	22.11 (5.65)		24.57 (6.21)	
Bus Story MLU	9 (2.28)	8		9	
Naming	8.45 (3.08)	4.95 (2.01)		8.80 (3.11)	
		Published norms for 4-year-olds		Published norms for 5-year- olds	
		4;0-4;05	4;06-4;11	5;0-5;05	5;06-5;11
RAPT information score	30.50 (3.73)	27 (5.33)	29 (5.32)	30 (5.02)	31 (4.97)
RAPT grammar score	22.79 (4.42)	20 (5.84)	21 (5.66)	23 (5.68)	24 (5.11)

4.2.3. Comparison of mean scores of a selection of speech output and speech input tasks of the Control group at T2 with a normative sample collected by Broadbent (2000)

Broadbent (2000) collected normative data on a sample of 20 children attending a reception class of a North London school. The aim of Broadbent's study was to examine the speech processing skills of 5-year-old children within an average classroom setting. No children were initially excluded from participating in the study, so that her sample included six children who were bilingual and one child who was trilingual. Forty-five percent of the sample were male and 55% were female. After analysing the distribution of scores, Broadbent identified three children who were performing much less well than the other 17 children. Table 4.7 reports the means and SDs of the sample excluding these three outliers (i.e. 47.06% male and 52.9% female). This sample therefore represents an average selection of normally developing 5-year-old children from one Reception classroom. Also reported in Table 4.7 are the means and SDs of the current control group at T2 for direct comparison with Broadbent's sample. With the exception of the nonverbal tasks, data from T2 was selected for this comparison as the children from the two samples were both aged five, although the T2 sample are slightly older. T1 nonverbal standard scores are reported here as nonverbal skills were not measured at T2. The two samples are very similar in terms of nonverbal ability. Very similar means were also obtained for the speech output and speech input tasks.

Replicating the level of performance so closely demonstrates that the current control group, whilst a matched-pairs sample, resemble the abilities of other normally developing children. In further analyses reported below that focus on the normal development of speech/language skills, it allows us to be confident that this sample forms a representative group of normally developing children.

Table 4.7.
Comparison of mean scores of a selection of speech output and speech input tasks of the Control group at T2 with a normative sample collected by Broadbent (2000)

Test	Current control sample (n=47)	Broadbent sample (n=17)
Age	5.69 (.38)	5.2 (2.2)
Block Design (standard score)	10.68 (2.73) *	11.18 (1.88)
Picture Completion (standard score)	12.21 (2.22) *	12.53 (2.60)
LF word repetition	90.86 (6.38)	89.12 (5.62)
LF nonword repetition	83.17 (8.66)	83.88 (5.79)
Articulatory naming	94.28 (3.91)	92.82 (4.20)
AD: picture	45.59 (3.83)	46.47 (1.84)
AD: ABX	17.93 (3.5)	18.10 (3.31)

* As measured at T1
Note : SDs in parentheses

4.2.4. Analysis of speech output skills

4.2.4.*1*. Distribution of scores

Distribution of the speech output tasks was uneven between groups and over time. For the control group, the word repetition task reached ceiling at T2, with 89% of control children scoring 95% or more. High scores were also obtained on nonword repetition, with 68% of the control group scoring 95% or more correct on the nonword repetition task. Transformations did not ameliorate the distributions so raw scores were used in all Analyses of Variance calculations. Table 4.8 reports in full the percentage of children by group who scored 95% or 100% correct on all the speech output tasks. The introduction of the LF word and matched nonword repetition task at T2 was successful in the aim of avoiding subsequent ceiling effects in the control group.

4.2.4.2. Lexicalisations on nonword repetition tasks

The number of lexicalisations was calculated that occurred on the two nonword repetition tasks, i.e. lexicalising a nonword and producing a word. These are reported for each group in Table 4.9. A small number of lexicalisations were evident at T1 on the nonword repetition task. At T2 (on both nonword repetition tasks), and at T3, number of lexicalisations was negligible, showing that nonword items were not processed lexically. No differences were found in number of lexicalisations across group (Nonword repetition T1: U = 1016.5, ns; Nonword repetition T2: U = 969, ns; LF nonword repetition T2: U = 960, ns; LF nonword repetition T3: U = 1044, ns).

Table 4.8.
Percentage of participants scoring more than 95% correct or scoring 100% correct on measures of speech output at T1, T2 and T3

	Speech disordered group		Control group	
	95%	100%	95%	100%
T1				
Word repetition pcc	0	0	34.04	12.8
Nonword repetition pcc	0	0	17.02	2.1
Articulatory naming	0	0	29.8	10.6
T2				
Word repetition pcc	27.7	2.1	89.4	48.9
Nonword repetition pcc	10.6	0	68.1	23.4
Articulatory naming	2.1	0	51.1	6.4
LF word repetition pcc	2.1	0	29.8	2.1
LF nonword repetition pcc	0	0	4.3	0
T3				
Articulatory naming	4.3	0	50	11.4
LF word repetition pcc	4.3	0	43.2	0
LF nonword repetition pcc	2.1	0	9.1	0

Table 4.9.
Means and SDs of the Speech disordered group and the Control group on lexicalisations in nonword repetition tasks

Task	Speech disordered group	Control group
Nonword repetition T1	1.72 (1.83)	2.28 (2.76)
Nonword repetition T2	.89 (1.09)	.68 (1.07)
LF nonword repetition T2	.15 (.36)	.30 (.51)
LF nonword repetition T3	.21 (.41)	.20 (.40)

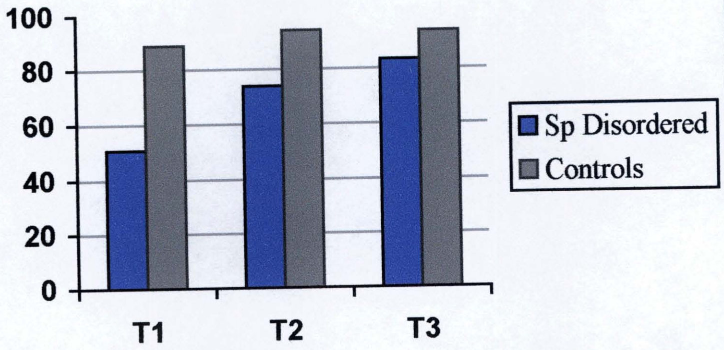
SDs in parentheses

4.2.4.3. Articulatory naming

A repeated measures ANOVA of the Articulatory naming task was conducted with one repeated measure and one between factor (Time (T1, T2, T3) x Group (Speech disordered, Controls)). There were 2 significant main effects: Time, ($F(2,88) = 108.81$, $p<.001$), and Group, ($F(1, 89) = 111.04$, $p<.001$). There was a significant interaction of Group x Time, ($F(2,88) = 53.41$, $p<.001$).

The Group x Time interaction was explored using simple effects. At T1, there was a highly significant difference between the speech disordered and control group ($F(1,89) = 149.29$, $p<.001$). The difference between the groups at T2, although still highly significant, was narrower, as illustrated by the smaller F value ($F(1,89) = 56.68$, $p<.001$) and at T3, the difference narrowed again ($F(1,89) = 33.82$, $p<.001$). Both groups showed significant improvement in scores over time, but this difference was greatest for the speech disordered group (Speech disordered: $F(2,178) = 195.23$, $p<.001$; Controls: $F(2,178) = 6.49$, $p<.005$). T-tests were conducted to look at differences between each of the three testing phases. Both groups showed significant improvement between T1 and T2 (Controls: $t(46) = -3.6$, $p<.001$; Speech disordered: $t(46) = -12.47$, $p<.001$). The speech disordered group showed significant improvement between T2 and T3 ($t(46) = -4.85$, $p<.001$) but there was no significant change for the control group ($t(43) = .23$, ns) as their scores approach ceiling. This interaction is illustrated in Figure 4.1.

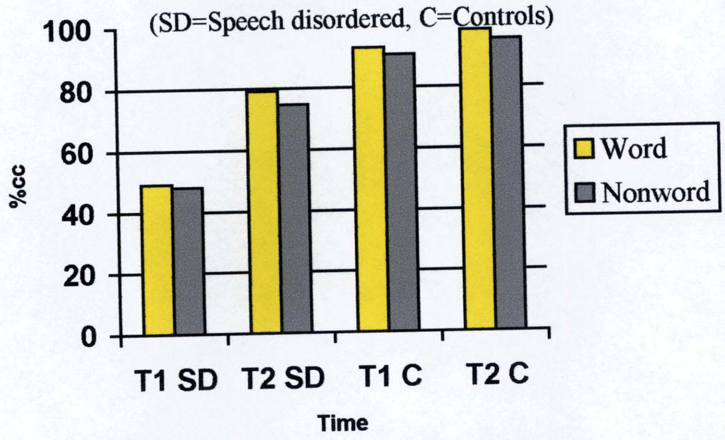
Figure 4.1.
Bar Chart of Articulatory naming over time and according to group



4.2.4.4. Word/nonword tasks T1/T2

A repeated measures ANOVA of the original repetition task was conducted with 2 repeated measures and one between factor (Time (T1, T2) x Word Type (Word, Nonword) x Group (Speech disordered, Controls)). There were 3 significant main effects: Time, ($F(1,92) = 280.56$, $p<.001$), Word Type ($F(1,92) = 44.35$, $p<.001$) and of Group, ($F(1, 92) = 3943$, $p<.001$). There was a significant interaction of Group x Time, ($F(1,92) = 130.48$, $p<.001$) and of Word Type x Time, ($F(1,92) = 6.94$, $p<.01$) but no significant interaction of Word type x Group ($F(1,92) = .001$, ns) i.e. there was an overall similar discrepancy between word and nonword repetition for controls and speech disordered. The 3-way interaction narrowly missed significance ($F(1,92) = 3.56$, $p=.062$).

Figure 4.2.
Bar Chart of Word and Nonword repetition at T1 and T2 by group
(SD=Speech disordered, C=Controls)



The two interactions were explored. The Group x Time interaction was explored using simple effects. At T1, there was a highly significant difference between the speech disordered and control group ($F(1,92) = 299.23$, $p<.001$) but the difference between the groups at T2, although still highly significant, was narrower, as illustrated by the smaller F value ($F(1,92) = 48.25$, $p<.001$). Both groups showed significant improvement in scores between T1 and T2, but this difference was greatest for the speech disordered group (Speech disordered T1 Vs T2: $F(1,92) = 396.85$, $p<.001$; Controls T1 vs. T2: ($F(1,92) = 14.19$, $p<.001$). Whilst these simple effects can be interpreted as a greater improvement of the speech disordered group than the controls and hence a narrowing (but still significant) gap between the two groups, caution must be applied as the control group are at ceiling on these tasks.

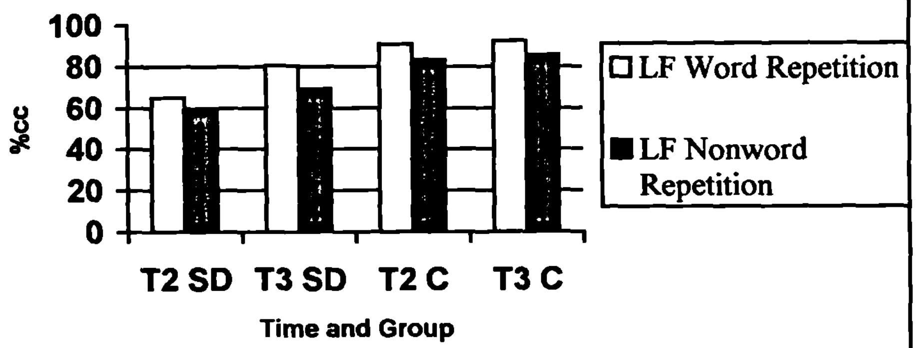
The Word type x Time interaction was also explored. For both word and nonword repetition, there were highly significant differences between T1 and T2 (Word repetition T1 vs. T2: ($F(1,92) = 265.17$, $p<.001$); Nonword repetition T1 vs. T2 ($F(1,92) = 226.07$, $p<.001$)). At T1, there was a significant difference between Word and Nonword repetition ($F(1,92) = 10.92$, $p<.001$) and a significant difference between the two word types at T2 ($F(1,92) = 40.01$, $p<.001$). However, it seems that the difference between the word types becomes greater at T2 and this increasing differentiation is where the interaction lies. This was confirmed by comparing differences between word and nonword performance at T1 and T2. There was a significant difference between word/nonword discrepancies at T1 and T2: $t\ (93) = 2.99$, $p<.005$. Since there was no 3-way interaction, differences related to group membership were not explored, and changes in word/nonword patterns were therefore not mediated by group.

4.2.4.5. Word/nonword repetition T2/T3

A repeated measures ANOVA was also conducted of the Extension to the repetition task that was administered at T2 and T3. This ANOVA had 2 repeated measures and one between factor (Time (T2, T3) x Word Type (Word, Nonword) x Group (Speech disordered, Controls)). There were 3 significant main effects: Time, ($F\ (1,89) = 66.47$, $p<.001$), Word Type ($F\ (1,89) = 230.31$, $p<.001$) and Group, ($F\ (1, 89) = 59.51$, $p<.001$). There was a significant interaction of Group x Time, ($F\ (1,89) = 31.37$, $p<.001$) but no significant interaction of Word Type x Time, ($F\ (1,89) = 3.71$, ns) or Word type x Group ($F\ (1,89) = 1.72$, ns) i.e. there were no changes in word/nonword pattern between T2 and T3 nor any differences in Group in the pattern of word/nonword repetition. There was a significant 3-way interaction of Word Type x Time x Group ($F\ (1,89) = 7.89$, $p<.01$).

The Group x Time interaction was explored. Both at T2 and T3, there were significant differences between the groups (at T2, $F\ (1,89) = 64.75$, $p<.001$; at T3, $F\ (1,89) = 39.92$, $p<.001$). The speech disordered group showed significant improvement over time (T2 vs. T3: ($F\ (1,89) = 97.8$, $p<.001$) but the control group did not show significant improvement over time (T2 vs. T3: ($F\ (1,89) = 3.15$, ns). However, this is mediated by the 3-way interaction of Word type x Time x Group. T-tests showed significant differences for the speech disordered group between T2 and T3 for both word and nonword repetition (Word: $t\ (46) = 7.66$, $p<.001$; Nonword: $t\ (46) = 6.14$, $p<.001$) and the controls also showed significant improvement on nonword repetition ($t\ (43) = 2.8$, $p<.01$). However, no significant change occurred for word repetition ($t\ (43) = 1.97$, ns). It is also noteworthy that the speech disordered group showed greater change than the controls on nonword repetition. These results are illustrated in Figure 4.3.

Figure 4.3.
Bar Chart of LF Word/Nonword repetition T2 and T3 by group
(SD = Speech disordered, C = Controls)



4.2.4.6. Rate of change across tasks

Rate of change of the speech disordered group was examined further. From the above ANOVAs, there appears to be a trend for greater improvement of the speech disordered group compared to the control group. The control group's performance plateaus at T3 on articulatory naming and word repetition, though there is still some improvement on nonword repetition.

The speech disordered group's performance was examined in more detail to see whether there was uniform improvement over time across different measures. Z-scores were calculated for the speech disordered group based on the control group's data. Differences for the control group between T1 and T2 and between T2 and T3 were calculated and the means and SDs were used for calculating z-scores for each speech disordered participant, i.e. the z-score represented the improvement between testing phases relative to the control group's performance. A z-score within a normal range would indicate a similar amount of improvement to the controls. A z-score in excess of 1 would indicate greater improvement relative to controls. A z-score below –1 would indicate less improvement relative to the controls (-1 SD taken as clinical significance). Table 4.10 reports the percentages of the children according to these rates of change between T1 and T2, and between T2 and T3.

Between T1 and T2 the majority of children with speech difficulties showed greater improvement than controls, with some exceptions. This pattern of improvement changed between T2 and T3. Fewer children were showing greater improvements and some actually showed significant decreases in scores. Changes over time in relation to the control group is mediated not only by the speech disordered group's development, but also by lack of variation in the control group as it reaches ceiling levels on these speech output tasks. The speech disordered group continues to improve, while the control group reaches ceiling levels. Rate of change in relation to speech outcome will be discussed in Chapter 7.

Table 4.10.
The Speech disordered group's pattern of change compared to the Control group's rate of change: percentage of children obtaining a similar rate of change, a greater rate of change or a slower rate of change compared to Controls

	Similar improvement (% of the Speech disordered group	Accelerated improvement (% of the Speech disordered group	Less improvement (% of the Speech disordered group
T1-T2			
Word repetition	10.6% (5)	89.4% (42)	0% (0)
Nonword repetition	14.9% (7)	85.1% (40)	0% (0)
Articulatory naming	25.5% (12)	74.5% (35)	0% (0)
T2-T3			
Word repetition	31.9% (15)	66% (31)	2.1% (1)
Nonword repetition	42.6% (20)	49% (23)	8.5% (4)
Articulatory naming	36.2% (17)	53.2% (25)	10.6% (5)

(n in parentheses)

4.2.5. Speech input skills

Children's speech input performance varied depending on the input task. The numbers of children scoring at chance or above chance was calculated for each task.

Effects of chance were calculated using the binomial distribution, with $p<.05$ as criterion. A score that obtained a significance level of $p<.05$ was considered to be above chance.

At T1, the majority of children were performing at a chance level on the AD: ABX task, but not on the AD: picture task, making the latter task a much more sensitive measure of speech input performance at age 4. By T3, the sensitivity of these two tasks had reversed. On the AD: ABX task there was a range of scores, but on the AD: picture task, the majority of children were achieving very high levels of accuracy. The AD: same/different task was more evenly distributed, with some children at chance, but also some at ceiling. Table 4.11 shows for each task the percentage of children at chance, and the percentage of children scoring at a high level of accuracy (a score of 95% or more correct, and a perfect score of 100% correct). Table 4.12 shows the mean performance of the groups by percentage of accurate responses, in order to be able to compare across tasks with differing numbers of items.

Despite the problem of task sensitivity, it was important to examine whether there were developmental changes in children's speech input processing over time, and whether this was related to group membership.

Table 4.11.
Percentage of participants scoring at a chance level, more than 95% correct or scoring 100% correct on measures of speech input at T1, T2 and T3

	Speech disordered group			Control group		
	Chance or below	95%	100%	Chance or below	95%	100%
T1						
AD: picture	8.51	17.02	0	0	34.04	6.4
AD: ABX	93.3	0	0	76.6	8.5	2.1
AD: S/D	53.2	14.9	8.5	32.6	34.04	17.4
T2						
AD: picture task	0	51.1	12.8	0	73.9	34.8
AD: ABX	51.1	2.1	2.1	34.8	8.7	0
AD: S/D	21.3	46.8	29.8	10.9	58.7	34.8
T3						
AD: picture task 2	0	76.6	31.9	0	77.3	40.9
AD: ABX	28.3	2.2	0	6.8	18.2	11.4

Table 4.12.
Mean percentage performance of the Speech disordered group and Controls on tests of speech input

	Speech disordered	Controls
	Mean %	Mean %
T1		
AD: picture	81.43 (12.98)	89.45 (9.04)
AD: ABX	57.78 (18.15)	65.60 (16.72)
AD: S/D	70.0 (19.53)	79.46 (17.77)
T2		
AD: picture	92.11 (7.55)	94.97 (7.97)
AD: ABX	66.58 (15.87)	74.73 (14.58)
AD: S/D	85.11 (14.91)	90.54 (11.89)
T3		
AD: picture	94.79 (5.0)	95.11 (5.55)
AD: ABX	76.81 (12.60)	85.23 (10.26)

Note: SDs in parentheses

4.2.5.*1*. AD: picture task

A repeated measures ANOVA of the AD: picture task was conducted with one repeated measure and one between factor (Time (T1, T2) x Group (Speech disordered, Controls)). Scores of *d'* were used. The AD: picture task of T3 was not included in this analysis, as the task involved the use of new stimuli. There were two main effects: Time, ($F(1,91) = 73.94$, $p<.001$), and Group, ($F(1,91) = 9.12$, $p<.005$). The interaction between Group and Time was not significant ($F(1,91) = .47$, ns).

No significant difference was found between groups on the T3 measure ($t(89) = -5$, ns). The mean percentage correct of the task at each testing phase shows that between T2 and T3, there was minimal improvement for both groups. This observation reflects some developmental change as the T3 version of the task had been devised with longer and more complex stimuli in an attempt to increase the difficulty of the task.

4.2.5.*2*. AD: same/different task

A repeated measures ANOVA of the AD: same/different task was conducted with one repeated measure and one between factor (Time (T1, T2) x Group (Speech disordered, Controls)). Scores of *d'* were used. No same/different task had been administered at T3. There were two main effects: Time, ($F(1,91) = 5.61$, $p<.05$), and

Group, (F (1,91) = 4.94, p<.05). The interaction between Group and Time was not significant (F (1,91) = 1.79, ns).

4.2.5.3. AD: ABX task

A repeated measures ANOVA of the AD: ABX task was conducted with one repeated measure and one between factor (Time (T1, T2, T3) x Group (Speech disordered, Controls)). The task administered at T1 was a subset of that used at T2 and T3. Therefore percentage scores were used in this analysis (using *d'* scores yielded the same results). There were two main effects: Time, (F (2,84) = 53.95, p<.001), and Group, (F (1,85) = 11.57, p<.001). The interaction between Group and Time was not significant (F (2,84) = .02, ns). Pairwise comparison (using a Bonferroni correction) found a significant difference between T1 and T2 (t = -8.58, p<.001) and between T2 and T3 (t = -10.73, p<.001).

4.2.5.4. Summary of speech input changes over time

Developmental change seems to be progressing at a similar rate for the two groups for AD: ABX and AD: same/different. There are significant gains in score for both groups on the AD: ABX over time, and significant gains on the AD: picture task and on the AD: same/different task between T1 and T2. Performance on AD: picture task, however, seems to plateau for both groups between T2 and T3, though, since at T3 an extension task was used, improvement may have occurred.

4.2.6. Language tasks

4.2.6.1. The Bus Story

Information score

A repeated measures ANOVA of the Bus Story (information score) was conducted with one repeated measure and one between factor (Time (T1, T2, T3) x Group (Speech disordered, Controls)). There were 2 significant main effects: Time, (F (2,86) = 98.34, p<.001), and of Group, (F (1, 87) = 12.40, p<.001). There was no significant interaction of Group x Time, (F (2,86) = 1.19, ns). Pairwise comparison (using a Bonferroni correction) found a significant difference between T1 and T2 ($t = -6.57$, $p<.001$) and between T2 and T3 ($t = -4.01$, $p<.001$).

MLU score

A similar analysis of the Bus Story MLU score revealed a significant main effect of Time, ($F(2, 87) = 89.81$, $p<.001$), and of Group, ($F(1, 88) = 19.67$, $p<.001$). There was also a significant interaction of Group x Time, ($F(2, 87) = 4.84$, $p<.01$).

The Group x Time interaction was explored using simple effects. At T1, there was a highly significant difference between the speech disordered and control group ($F(1, 88) = 30.73$, $p<.001$). The difference between the groups at T2, although still significant, was narrower as illustrated by the smaller F value ($F(1, 88) = 10.49$, $p<.005$). At T3, the difference between the two groups was no longer significant ($F(1,88) = 3.89$, $p=.052$). T-tests showed that both groups made significant improvement between T1 and T2 (Speech disordered: $t(45) = -6.92$, $p<.001$; Controls: $t(46) = -4.03$, $p<.001$) and between T2 and T3 (Speech disordered: $t(45) = -5.14$, $p<.001$; Controls: $t(43) = -3.64$, $p<.001$).

4.2.6.2. Renfrew Action Picture Test

Information score

A repeated measures ANOVA of the Renfrew Action Picture Test (information score) revealed 2 significant main effects: Time, ($F(2,88) = 73.76$, $p<.001$), and of Group, ($F(1, 89) = 4.96$, $p<.05$). There was no significant interaction of Group x Time, ($F(2,88) = 2.31$, ns). Pairwise comparison (using a Bonferroni correction) found a significant difference between T1 and T2 ($t = -3.68$, $p<.001$) and between T2 and T3 ($t = -1.62$, $p<.001$).

Grammar score

A repeated measures ANOVA of the Renfrew Action Picture Test (grammar score) revealed 2 significant main effects: Time, ($F(2,88) = 82.32$, $p<.001$), and of Group, ($F(1, 89) = 35.02$, $p<.001$). There was a significant interaction of Group x Time, ($F(2,88) = 10.81$, $p<.001$).

The Group x Time interaction was explored using simple effects. At T1, there was a highly significant difference between the speech disordered and control group ($F(1, 89)$

= 41.08, $p<.001$). The difference between the groups at T2, although still significant, was narrower as illustrated by the smaller F value ($F(1, 89) = 19.04$, $p<.001$). At T3, the difference between the two groups was still significant ($F(1,89) = 8.85$, $p<.01$).
T-tests showed that both groups made significant improvement between T1 and T2 (Speech disordered: $t(46) = -9.36$, $p<.001$; Controls: $t(46) = -4.47$, $p<.001$). Whilst the speech disordered group continued to make significant improvement between T2 and T3 (Speech disordered: $t(46) = -2.78$, $p<.01$), the controls did not ($t(43) = -.78$, ns).

4.2.6.3. Naming Test

A repeated measures ANOVA of the Naming Test revealed 2 significant main effects: Time, ($F(2,88) = 176.08$, $p<.001$), and of Group, ($F(1, 89) = 18.80$, $p<.001$). There was no significant interaction of Group x Time, ($F(2,88) = .54$, ns).

4.2.6.4. Test for Reception of Grammar (TROG)

A repeated measures ANOVA of the TROG (using number of items correct as the unit of analysis) revealed 2 significant main effects: Time, ($F(2,86) = 152.44$, $p<.001$), and of Group, ($F(1, 87) = 6.81$, $p<.05$). There was no significant interaction of Group x Time, ($F(2,86) = .74$, ns). Pairwise comparison (using a Bonferroni correction) found a significant difference between T1 and T2 ($t = -12.74$, $p<.001$) and between T2 and T3 ($t = -7.23$, $p<.001$).

4.2.6.5. British Picture Vocabulary Scale (BPVS)

A repeated measures ANOVA of the BPVS revealed 2 significant main effects: Time, ($F(2,87) = 384.5$, $p<.001$), and of Group, ($F(1, 88) = 17.75$, $p<.001$). There was no significant interaction of Group x Time, ($F(2,87) = 1.74$, ns). Pairwise comparison (using a Bonferroni correction) found a significant difference between T1 and T2 ($t = -12.92$, $p<.001$) and between T2 and T3 ($t = -10.73$, $p<.001$).

4.2.7. Nonverbal measures

To assess possible changes in nonverbal performance between T1 and T3, a composite measure of the two nonverbal measures, Block Design and Picture Completion, was calculated using the standard scores obtained. Nonverbal ability was assessed at T1 using the WPSSI-R and at T3 using the WISC-III^{UK}. A repeated measures ANOVA revealed two significant main effects of Time ($F(1,89) = 134.84$, $p<.001$) and of Group ($F(1,89) = 4.03$, $p<.05$). There was also a significant interaction of Time x Group ($F(1,89) = 7.96$, $p<.01$). Simple effects revealed that the performance of both groups changed over time (Speech disordered: $F(1,89) = 107.72$, $p<.001$; Control: $F(1,89) = 37.41$, $p<.001$). Examination of mean standard scores (as reported in Table 4.13) shows that there was a drop in level of performance. Whilst the speech disordered group and the control group were not significantly different at T1 on the composite measure ($F(2,88) = .72$, ns) (the groups were matched on this composite), a significant difference had emerged at T3 between the groups ($F(2,88) = 7.25$, $p<.01$) with the speech disordered group scoring less well than the controls.

Table 4.13.
Means and SDs on nonverbal tasks by group: standard scores

Test	Speech disordered group	Control group
Block design T1	10.28 (2.29)	10.68 (2.73)
Picture completion T1	12.11 (2.11)	12.21 (2.22)
Block design T3	8.7 (3.3)	9.84 (2.98)
Picture completion T3	8.83 (2.42)	10.25 (2.64)

SDs in parentheses

4.3. Discussion

4.3.1. Methodological issues

Whilst the control group was not randomly selected, comparison of this group's performance on the test battery with other normally developing samples showed similar levels of attainment. First, on the standardised measures, the control group's performance was broadly in line with the standardisation samples. Second, comparison of performance on the experimental tasks was made with a normative sample collected by Broadbent (2000). Again, similar levels of performance were noted, giving further evidence that the matched-pairs control sample was performing in a typical way.

4.3.2. Task design

4.3.2.1. Speech output

Given that the most significant period of speech development is in the early years, it was not surprising to encounter ceiling effects by T2 on the original version word and nonword repetition task for the control group. These tasks, particularly the word repetition task, also showed poor reliability at T2 for this group. High levels of accuracy should be reflected in high levels of reliability (Kline, 2000). This was not the case for these versions of the repetition tasks for the control group. The use of low frequency, multisyllabic words and matched nonwords in the extension repetition tasks did continue to stretch the controls' speech output skills and also produced more adequate levels of reliability. Through these extension tasks it was thus possible to tap into continuing speech output development with an acceptable level of reliability.

For the speech disordered group, the speech output measures were highly reliable. Whilst each child's speech difficulties might be specific to certain sounds or certain processes were prominent, the tasks included an adequate selection of consonants for each child to perform at a consistent level across the task. When the tasks were split (for administration and for calculating reliability) children performed similarly on both halves.

4.3.2.2. Speech input

Both chance and ceiling effects were encountered in this data. At T1, as predicted, many children made guesses on the AD: ABX task. This, combined with the small number of items, made the reliability of the test low. Because of these chance effects, it is unlikely that this task was tapping into speech input ability, especially as so many of the controls were also unsuccessful. Instead of tapping phonological discrimination/recognition and bottom-up processing, it is probable that the task was assessing how well the child understood what was being asked of him/her as well as attention skills and memory load. Whilst 77% of controls were at chance on the AD: ABX task, only 33% were at chance on the AD: same/different task at T1. Thus Locke's (1980) hypothesis was borne out that the conceptual demands of the AD: ABX task are greater than the problems of understanding the terms 'same' and 'different'. The AD: picture task, a test promoted by Locke, was more successful at avoiding intrinsic task difficulties at T1, with no control children at chance and only 8% of the speech disordered group. However, at T2, and to an even greater extent at T3, performance on this task approaches ceiling, whilst the AD: ABX task becomes a more sensitive measure, and appears to be tapping what it purports to tap, rather than general cognitive or attention levels.

The fact that the speech input tasks were intended to tap different processing levels, yet show different task complexity is problematic. It is not possible simply to make direct comparisons between processing levels, without taking task sensitivity into account. Yet the advantage of choosing several tasks with different degrees of complexity is clear. As discussed below, it allows us to identify deficits in the input channel over time which might otherwise go undetected. If the AD: ABX task alone had been administered at T1, identifying any input deficits would have been difficult, in the context of the chance effects. Results from the other two tasks allow for more confidence in describing input deficits. If only the AD: picture task had been included at T3, one might have erroneously concluded that there were no differences on input between the groups at age 6. At this age, it is the AD: ABX task, now more reliable and with a better distribution, that reveals continued speech input deficits in the speech disordered group.

4.3.2.3. Language

For BPVS and TROG, reliability measures were available and showed good levels of reliability, which were at a comparable level to many of the experimental tasks (with the exception of those with lower levels of reliability described above). For the Bus Story and the RAPT, no reliability measures were available. These tests are not well standardised: no standard scores or percentile ranks are published, but some age equivalent scores can be calculated. It is unclear whether these tests are accurate quantitative measurement tools; they certainly yield useful qualitative data for clinical purposes. The tasks draw on a diverse range of speech and language skills compared to the experimental tasks where more precise speech processing skills were targeted. Nonetheless, their inclusion was justified as they are quick-to-administer language assessments and have been used in other studies of this kind (e.g. Bishop & Edmundson, 1987a). The Bus Story has also previously been identified as a useful predictor of later language outcome (Bishop & Edmundson, 1987a).

4.3.3. Normal development

4.3.3.1. Speech output

Continuing development of speech output skills was noted in the control group between T1 and T2 on all three speech output tasks. However, between T2 and T3 increases in scores were nonsignificant for the LF word repetition task and the articulatory naming task. Performance continues to improve significantly on the LF nonword repetition task. The control group is therefore starting to plateau on lexically based speech output tasks.

Turning to the comparisons of word and nonword repetition performance, it is clear from the two repetition tasks that the controls are poorer at repeating nonwords than words. The discrepancy between word and nonword performance was greater for the extension repetition tasks than the original versions. This was found despite the word stimuli being low frequency. The low frequency words could have been treated as nonwords by the children, but, because of the discrepancy, it seems that, at least for part of the list, they were processed lexically.

There did seem to be a slightly increasing discrepancy between the original version of the word and nonword repetition performance with age across groups. This is confirmatory of Vance et al.'s (1995) findings. They also found that the discrepancy between word and nonword repetition increased with age in their normally developing sample. However, an inspection of the means shows this to be a relatively minor increase in the discrepancy between the measures. Vance's (2001) data showed that the greatest increase in discrepancy occurred between the ages of three and four, with 3-year-olds showing no significant difference between word and nonword, and less change occurring in older children. Thus, the smaller change in discrepancy noted here is consistent within this general developmental trend. Further analyses in Chapters 7 and 8 will explore word/nonword discrepancy and changes over time and reveal some important changes in these patterns over time and when subgroup performance is examined.

4.3.3.2. Speech input skills

Despite the issue of task sensitivity, continued improvement of speech input skills in normal development has been demonstrated. For all tasks, there was increased accuracy of performance between T1 and T2. The AD: picture task can be interpreted as showing some developmental sensitivity at T3. Although there was little change in scores, a new version of the task was being used at T3 with longer and more complex words in an attempt to increase the difficulty of the task. The AD: ABX task did show children improving through to T3.

This apparent continued development of speech input skills might seem surprising. One could argue that, by T3, when the children are aged six-and-a-half, speech skills are well developed and one would expect the development of speech input skills to be complete. Indeed performance levels off on the speech output measures. The results could be explained by raising the issue of task design again. The errors that normally developing children make could be due to the increased memory load of this particular task, together with possible lapses in attention during administration of the task. However, evidence from the literature supports an argument for the continuing development of speech perception abilities, albeit that these abilities become 'contaminated' by higher cognitive factors and top-down lexical influences (Fowler, 1991; Walley, 1993). It has been suggested that children's processing skills continue to develop for some time, with a gradual reorganisation of the speech perceptual system (Hazan & Barrett, 2000) and speech segmentation becoming more detailed with age (Walley, 1993). Whilst the speech output data showed slowing improvement, significant gains were still made on nonword repetition. Other evidence supports the view that, not just input skills, but other speech processing abilities continue to develop. Further improvement, whilst less rapid than before, is thus still to be expected. Even at T3, not all normally developing children have reached ceiling on the other speech output tasks.

Moreover, it could be argued that this further development in speech input processing is in fact still occurring in bottom-up processing, rather than top-down processing. Evidence for this comes from the AD: ABX task which uses nonword stimuli. As it uses nonwords, it is placed at the lower level of 'phonological recognition' on Stackhouse and Wells' model (see Figure 4.4), because it is not possible to use stored, lexical knowledge to complete the task. Phonological representations, by age 6, seem firmly established: ceiling effects occurred on the AD: picture task, where top-down processing is required. The AD: ABX task, a task requiring on-line processing, without the support of phonological representations, and combined with a memory component, still produces errors. If one removes the influence of top-down processing, then normally developing children show less than perfect input processing skills. However, this type of processing must be adequate and sufficient to process language, to set up accurate phonological representations and to have well-developed speech output skills. Yet further development of speech input skills may still need to occur for children to be able to process, store and articulate more complex and/or unfamiliar words. To reiterate, nonword repetition performance continued to improve between T2 and T3 for the control group, suggesting continued development of the speech processing system through middle childhood.

Do normally developing children also show improved top-down processing? Normally developing children move from showing some errors on the AD: picture task at T1 to near-perfect scores at T3. This could reflect increased accuracy in the way phonological representations are stored. However, this task involves discrimination skills as well as the accessing of phonological representations. Thus, alternatively, errors may actually reflect the relatively poorer ability the children have with discrimination, i.e. at processing at the level of 'phonological recognition' (also measured by the AD: ABX task). If this is the case, then increased scores reflect development at the level of 'phonological recognition' (also improving as measured by the AD: ABX task), rather than with the refinement of phonological representations. Since top-down processing is used by accessing representations, the child relies less on these developing 'phonological recognition' or bottom-up skills, hence the ceiling effects achieved at later testing phases. These contrasting hypotheses will have implications for how we interpret the pattern of performance on speech input tasks in the speech disordered group.

Figure 4.4.
Stackhouse and Wells' speech processing model (1997): speech input processing.

Image has been removed for copyright reasons

4.3.3.*3*. Language

The language measures chosen aimed to measure both expressive and receptive language, and syntax and vocabulary. With the exception of RAPT grammar, the control group's scores improved over the course of the study, suggesting that these measures continue to develop between the ages of 4 and 6. Only on the RAPT (grammar score) is lack of change revealed between T2 and T3.

4.3.3.*4*. Nonverbal skills

Nonverbal skills were assessed mainly as a control measure. One would not expect any changes in the standard scores obtained by the control group on the composite measure. Finding a significant difference between T1 and T3 on this composite measure, with a decrease in level of performance is therefore surprising, though, in a longitudinal study, Johnson, Beitchman, Young et al. (1999) reported similar findings for both their SLI group and their normally developing control group.

The fall in scores could be attributable to the use of different versions of the tests at T1 and T3 (WPSSI-R at T1 and the WISC-III^{UK} at T3). Comparisons reported in the WISC-III manual (Wechsler, 1992) between full scale IQ scores of the two versions show an average difference of 4 points obtained when both tasks were administered to a sample of 188 6 –year-olds. Measurement error may therefore play some role, though one would expect both groups to be affected equally by such measurement error.

4.3.4. Group differences over time

4.3.4.*1*. Speech output

The 3 sets of analyses comparing the speech disordered group and the control group (for articulatory naming, word/nonword repetition and LF word/nonword repetition) revealed similar patterns of difference. As expected, the speech disordered and control groups were significantly different across all speech output tasks and over all measuring points. However, the difference between the groups narrowed over time. The speech disordered group appeared to show dramatic and significant improvement.

Relative to controls, their performance appeared accelerated between T1 and T2, and to a lesser extent, between T2 and T3. This seemingly dramatic improvement must be interpreted in the context of the slowing of change in the control group. Overall, the control group is starting to plateau, giving the speech disordered group a chance to make significant gains. This pattern of greater improvement shows that the speech disordered group is not exhibiting a normal rate of change, nor is there indication of arrested development. Indeed, a significant proportion of the speech disordered group has resolved speech at T2 and T3: whether there is accelerated improvement in those children whose speech resolves is examined in Chapter 7. Another important observation was that there was greater variance (as measured by SD) in the speech disordered group's performance on output tasks than by the control group. In terms of speech output development, the disordered group is more heterogeneous than controls.

Turning to the comparisons of word and nonword performance, it is clear from the 2 repetition tasks that the speech disordered group, like the controls, repeat nonwords less accurately than words. The two groups show a similar pattern of performance with no difference between the groups in the relationship between word and nonword repetition (though this is examined in further detail in Chapter 8) and on number of lexicalisations. No conclusions can be drawn on the relationship between repetition and naming skills as the two tasks did not use the same stimuli.

4.3.4.2. Speech input

There were group differences on at least one of the speech input tasks at each testing phase. At T1, there were differences on the AD: picture task and the AD: same/different task. At T2, there were differences on all three tasks. At T3, there were group differences on the AD: ABX task. Different tests therefore reveal group differences at different ages and this is strongly affected by task sensitivity, with both chance and ceiling effects noted. If the AD: ABX task alone had been administered, no input deficits would have been identified at age 4. The other two tasks show that there were deficits at this age. If only the AD: picture task had been included, one might have erroneously concluded that there were no differences on input between the groups at age 6. Despite considerable improvements on speech output skill over the course of the study, with some children even resolving in their difficulty, children with speech difficulties still lagged behind on speech input skills. These findings confirm studies that have found differences between children with speech difficulties and controls (Bird & Bishop, 1992).

Variance was similar on the speech input tasks across groups. Thus, while performance was depressed for the speech disordered group, they were not more heterogeneous in performance than the normally developing group.

4.3.4.3. Language

The speech disordered group as a whole perform significantly less well than matched controls on both expressive and receptive language measures at T1. These difficulties also appear to be persisting ones, as group differences are also found at T2 and T3 on the majority of tasks.

Findings of expressive language problems in this population confirm the literature on the co-occurrence of language difficulties with speech problems. Several studies have shown that children with speech difficulties may have other expressive language difficulties (e.g. Bird, Bishop & Freeman, 1995; Shriberg et al., 1999), and this is the case in this study where the speech disordered group scored less well than controls on the Bus Story, the RAPT and the Naming task. Receptive language problems were also noted.

As with the input tasks, SDs were broadly similar for the two groups on language measures. Whilst the speech disordered group scored less well on these tasks, there was not greater variation in performance.

4.3.4.4. Nonverbal skills

At T1, the two groups were matched on their nonverbal skills. By T3, the two groups appear no longer to be matched on this aspect. Both groups' performance in terms of standard scores appear to have decreased, with the speech disordered group's performance decreasing to a greater extent. It is not easy to interpret this result, in part because the measures are from different versions of the Wechsler test, though the difference is a noteworthy one. The result also confirms findings from other follow-up studies of children with SLI which have found decreases in nonverbal performance (Stothard, Snowling, Bishop et al., 1998; Conti-Ramsden, Botting, Simkin & Knox, 2001). This decrease is said to reflect problems with the development of inner speech and may also be influenced by the type of nonverbal assessment used. Whilst there is some evidence that nonverbal scores decrease in normal development as well as children with SLI (Johnson, Beitchman, Young et al., 1999), the fact that the speech disordered group's scores decreased more shows that this is not simply a normal trend.

4.3.5. Summary

An overall trend is noted of continued language development for both groups. On speech output tasks, patterns of development change, with differences narrowing between the groups. The control group's scores reach ceiling as their speech skills become extremely accurate, whilst the speech disordered group continue to improve, with no evidence for arrested development. Importantly, the speech disordered group shows huge variance on the speech output measures, but similar variance to controls on measures of language and speech input.

Chapter 5
Supplementary data collected through questionnaires: Birth order, developmental history, family history, psychosocial status and therapy

5.1. Introduction

This chapter presents data collected through questionnaires completed by parents, speech and language therapists and teachers. The questionnaires provide information on the children's developmental history, family history of speech or literacy difficulties, therapy intervention and psychosocial development. This information was considered to be supplementary to the main themes of the thesis, which focus on speech processing and language skills. However, there is some evidence from the literature that such factors should be considered in describing the difficulties of children with speech difficulties. It is also possible that such factors may be influential in predicting the course of development of these children's speech difficulties, an issue that will be addressed in Chapter 7, where speech outcome is examined. In this chapter, group differences between the speech disordered group and the control group on these supplementary measures are explored where appropriate and relationships between these measures and speech skills are examined. Therapy provision (amount, type and location) is described for the speech disordered group and related to level of speech difficulty.

Information on aspects of developmental history was collected because of its potential influence on speech development. Information was obtained on hearing status, early developmental milestones and health. Since research has examined the relationship between hearing difficulties such as otitis media and phonological development (e.g. Mody, Schwartz, Gravel & Ruben, 1999; Shriberg et al., 2000ab), it was important to examine whether the speech disordered group had a higher incidence of early hearing problems compared to the control group. Birth order has been weakly associated with speech and language impairment (Shriberg et al., 1994; Tomblin, 1990) and so is examined here. Family history of speech difficulties has also been noted in children with speech difficulties (Lewis, Ekelman & Aram, 1989; Lewis, 1992) and this information was collected. It has been reported that children with language difficulties, and, to a lesser extent, children with speech difficulties are more likely than other children to have some type of psychosocial difficulty (Cantwell & Baker, 1987). Psychosocial skills were thus examined through Goodman's (1997) Strengths and Difficulties Questionnaire (SDQ). Type and amount of therapy received by the speech disordered group varied but detailed information was collected on the intervention each child was receiving in order to describe and measure this intervention and examine its effects on development.

5.1.1. Research questions

1. Are there differences between the speech disordered group and the control group on developmental measures (birth order, birth history, health, physical development, hearing development and vision)?
2. Are there differences between the speech disordered group and the control group on incidence of family history of speech or reading difficulties?
3. Are there differences between the speech disordered group and the control group on psychosocial measures as assessed through the Strengths and Difficulties Questionnaire (Goodman, 1997)?
4. What constitutes the therapy provision of the speech disordered group?
5. Are there relationships between the questionnaire data and level of speech skill in the speech disordered group and the control group?

5.2. Group differences between the Speech disordered and the Control group

5.2.1. Birth order

Table 5.1 shows birth order information of the two groups of children in the study. First, it is important to note that children with speech difficulties had significantly more siblings than the control group ($U = 500.5$, $p<.05$). Distribution of birth order also varies by group. More children in the control group were first-born children than children in the speech disordered group. This pattern was reversed for second-born children with the majority of the speech disordered group reported to be second-born. Distributions were similar for both groups for third-born children and children fourth-born or over. A Chi-square was calculated on first-, second- and third-born only, due to small numbers for fourth-born and over. A significant difference was found between the two groups (χ^2 (2) = 13.97, p<.001).

Table 5.1.
Number of siblings and birth order data for the Speech disordered and Control groups

	Speech disordered	Controls
	Mean (SD)	Mean (SD)
No. of siblings	1.83 (.97)	1.29 (.86)

Birth order	% (n in parentheses) (total n=41)	% (n in parentheses) (total n=35)
1st born	15 (6)	51 (18)
2nd born	59 (24)	23 (8)
3rd born	17 (7)	23 (8)
4th born +	8.5 (4)	2.1 (1)

5.2.2. Developmental history

Table 5.2 shows information on developmental history. Where expected values were sufficient, Chi-squares were calculated; where insufficient, Fisher's exact test was used, due to the 2 x 2 design of the analysis.

Birth and general health details: A significant group difference was noted on frequency of coughs and colds (χ^2 (1) = 4.86, p<.05). No other group differences were noted (for those measures where Chi-square was calculated, χ^2 is reported as follows: Asthma: χ^2 (1) = .34, ns; Ear infections: χ^2 (1) = .21, ns).

Physical development: Fisher's exact test was used to calculate differences between groups on measures of physical development, with the exception of estimated age when child first walked where a Mann-Whitney test was calculated (U = 596, ns). No significant group differences were noted on any measures of physical development.

Hearing: Fisher's exact test was used to calculate differences between groups on measures of hearing, with the exception of 'concern over hearing' where a Chi-Square test was calculated. No significant differences were noted ('concern over hearing': χ^2 (1) = 2.3, ns).

Speech and language: Children with speech difficulties were reported to be, on average, eight months older than controls when first words were noted. A Mann-Whitney test verified this as a significant difference ($U = 221.5$, $p<.001$). Concern over speech was found to differ significantly between groups, using Fisher's exact test ($p<.001$). As no controls were recorded as having current problems or treatment, no significance test was performed. Fifty-five percent of parents of the speech disordered group were no longer concerned about their child's speech difficulties at the time of this questionnaire (T3).

Vision: Chi-square was calculated for 'concerns over vision' and a significant difference was noted between groups (χ^2 (1) = 4.02, $p<.05$). Using Fisher's exact test, no significant differences were noted on current problems with vision or treatment sought or given.

5.2.3. Family history data

Information on family history is reported in Table 5.3. Where expected values were sufficient, Chi-squares were calculated (all nonsignificant) as follows: Reading difficulties (mother's family) ($\chi^2(1) = 3.4$, $p =.07$), speech difficulties (mother's siblings), ($\chi^2(1) = .05$, ns), speech difficulties (mother's family) ($\chi^2(1) = .55$, ns) and reading difficulties (father's family) ($\chi^2(1) = .45$, ns). Other measures where Fisher's exact test was used also revealed no significant differences.

Information was also collected on incidence of speech/literacy difficulties of siblings of the children. It was found that 44.7% of the speech disordered group had a sibling or siblings with speech or literacy difficulties compared to only 11% of the controls. A Chi-square test showed a significant difference between groups ($\chi^2(1) = 10.48$, $p<.001$). This result needs to be qualified by the fact that children with speech difficulties tended to have more siblings than the control group.

Table 5.2.
Developmental information of the Speech disordered and Control group

Measure	Speech disordered group (total n=41)	Controls (total n=35)
	*% of yes responses	*% of yes responses
Birth & general health details		
Premature	17.1 (7)	5.7 (2)
Birth complications	10 (4)	17.1 (6)
Feeding difficulties	19.5 (8)	5.7 (2)
Allergies	15 (6)	5.7 (2)
Fits	0 (0)	0 (0)
Asthma	22.5 (9)	17.1 (6)
Frequent coughs and colds	29.3 (12)	8.8 (3)
Ear infections	24.4 (10)	20.0 (7)
Catarrh	7.3 (3)	2.9 (1)
Physical development		
**Age when first walked	13.03 (3.33)	12.35 (2.48)
Concerns over physical development	14.6 (6)	5.7 (2)
If yes, was:		
Treatment sought	100 (6)	50 (1)
If yes, was:		
Treatment given	83.3 (5)	100 (1)
Current problems	50 (3)	100 (1)
Hearing		
Concerns over hearing	39 (16)	22.9 (8)
If yes, was:		
Treatment sought	93.3 (14)	100 (8)
If yes, was:		
Treatment given	93.3 (14)	100 (8)
Current problems	6.7 (1)	33.3 (2)
Speech and language		
**Age of first words	21.64 (9.68)	13.02 (5.71)
Concerns over speech or language	97.6 (40)	2.9 (1)
If yes, was:		
Treatment sought	97.6 (40)	0 (0)
If yes, was:		
Treatment given	92.7 (38)	0 (0)
Current problems	45.0 (18)	0 (0)
Vision		
Concerns over vision	22.0 (9)	5.7 (2)
If yes, was:		
Treatment sought	100 (9)	100 (2)
If yes, was:		
Treatment given	88.9 (8)	50 (1)
Current problems	77.8 (7)	50 (1)
Current problems	100 (9)	50 (1)
Glasses wearer	10.3 (5)	4.4 (2)
Other		
Right Handed	87.2	79.5

* unless otherwise stated ** mean and SD (months) Numbers of participants are given in parentheses

Table 5.3.
Percentage of the Speech disordered and Control groups with a family history of speech/literacy difficulties

Mother's questionnaire		
Measure	**Speech disordered group (total n=40)**	**Controls (total n=35)**
	% of yes responses	**% of yes responses**
Reading difficulties (self)	10 (4)	11.4 (4)
Reading difficulties (parents)	17.5 (7)	2.9 (1)
Reading difficulties (grandparents)	2.5 (1)	2.9 (1)
Reading difficulties (siblings)	17.5 (7)	8.6 (3)
Reading difficulties (any family member)	32.5 (13)	14.3 (5)
Speech difficulties (self)	9.8 (4)	2.9 (1)
Speech difficulties (parents)	7.5 (3)	0 (0)
Speech difficulties (grandparents)	2.5 (1)	0 (0)
Speech difficulties (siblings)	10 (4)	8.6 (3)
Speech difficulties (any family member)	17.5 (7)	11.4 (4)
Attendance at speech therapy clinic (self)	7.5 (3)	2.9 (1)
Hearing loss (self)	10 (4)	14.3 (5)
Father's questionnaire		
Measure	**Speech disordered group (n=33)**	**Controls (n=28)**
	% of yes responses	**% of yes responses**
Reading difficulties (self)	6.1 (2)	10.7 (3)
Reading difficulties (parents)	12.5 (4)	3.6 (1)
Reading difficulties (grandparents)	3.1 (1)	7.1 (2)
Reading difficulties (siblings)	15.6 (5)	3.6 (1)
Reading difficulties (any family member)	25 (8)	17.9 (5)
Speech difficulties (self)	9.1 (3)	0 (0)
Speech difficulties (parents)	0 (0)	0 (0)
Speech difficulties (grandparents)	0 (0)	0 (0)
Speech difficulties (siblings)	3.2 (1)	7.1 (2)
Speech difficulties (any family member)	6.5 (2)	7.1 (2)
Attendance at speech therapy clinic (self)	9.1 (3)	0 (0)
Hearing loss (self)	9.4 (3)	10.3 (3)

Numbers of participants are given in parentheses

5.2.4. Psychosocial data

Children were categorised into 3 bands (normal, borderline and abnormal) as described by Goodman (1997) and this data is reported in Table 5.4[5]. These bands were designed in the Goodman study so that roughly 80% of children would fall into the 'normal' category, 10% in the 'borderline' and 10% in the 'abnormal' band. This was roughly replicated in this study, with the exception of 'hyperactivity' where more than 10% were recorded as having difficulties in both groups (Speech disordered: 15.6%; Controls: 18.2%). For statistical analysis, ratings rather than this categorisation were used for maximum sensitivity. Ratings ranged from 0 to a possible 10 for all subcategories with 0 being no difficulty (except for Prosocial behaviour where 0 represented the greatest degree of difficulty). Total difficulties score ranged from 0 to a possible 40 and contained the total score of all subcategories, except prosocial development. Means and SDs are reported in Table 5.5. Overall, on a Mann-Whitney test, the speech disordered group did not score more poorly on psychosocial presentation than the controls (Total SDQ score: $U = 907.5$, ns). There was a significant difference on the conduct score with a higher incidence of difficulties in the control group ($U = 779.5$, $p<.05$) but no significant differences on other measures (Emotional symptoms: $U = 769.5$, ns; Hyperactivity: $U = 953.5$, ns; Peer problems: $U = 902$, ns; Prosocial behaviour: $U = 921.5$, ns).

Table 5.4.
Percentage of Speech disordered and Control groups on Strengths and Difficulties Questionnaire (SDQ) scales

	% of Speech disordered group (total n=45) (n in parentheses)			% of Controls (total n=44) (n in parentheses)		
	Normal	Borderline	Difficulties	Normal	Borderline	Difficulties
Emotional symptoms	77.8 (35)	13.3 (6)	8.9 (4)	88.6 (39)	2.3 (1)	9.1 (3)
Conduct problems	91.1 (41)	4.4 (2)	4.4 (2)	88.6 (39)	2.3 (1)	9.1 (4)
Hyperactivity	71.1 (32)	13.3 (6)	15.6 (7)	75 (33)	6.8 (3)	18.2 (8)
Peer problems	84.4 (38)	11.1 (5)	4.4 (2)	93.2 (41)	2.3 (1)	4.5 (2)
Prosocial behaviour	75.6 (29)	17.8 (8)	6.7 (3)	70.5 (31)	13.6 (6)	15.9 (7)
Total difficulties	71.1 (32)	17.8 (8)	11.1 (5)	77.3 (34)	15.6 (7)	6.8 (3)

Table 5.5.

[5] Acknowledgement: John Adams, formerly of the Centre for Reading and Language, University of York (and now of the Department of Psychology, University of Durham) scored the SDQ data.

Means and SDs of ratings on Strengths and Difficulties Questionnaire (SDQ) scales by Speech disordered and Control groups

	Speech disordered group (n=45)	Control group (n=44)
Emotional symptoms	2.47 (2.31)	1.70 (2.23)
Conduct problems	.51 (1.24)	.95 (1.43)
Hyperactivity	3.33 (3.10)	3.16 (3.13)
Peer problems	1.49 (1.89)	1.11 (1.45)
Prosocial behaviour	7.58 (2.14)	7.27 (2.33)
Total difficulties	7.80 (5.99)	6.93 (5.50)

Note: SDs in parentheses

5.3. Therapy data: Speech disordered group

Information collected on amount, type and location of therapy is reported in Table 5.6. Children had been referred to speech and language therapy at the age of about 3 years. Amount of therapy received generally decreased with age, and is a reflection of how some children's speech difficulties resolved. However, large standard deviations were noted, showing the disparate amount of therapy received across the group, with some children receiving intensive therapy within a language unit, and others spending time on a waiting list. Table 5.7 presents the amount of therapy received for those children who were receiving therapy in the traditional setting of the community clinic (80% of the sample). SDs are still large, but it is apparent that children are receiving an average of less than eight sessions of individual therapy (of approximately 40-50 minutes) for each time period. The number of group sessions was even lower, showing that group intervention was greater for those attending specialist settings than for those receiving therapy within a community clinic. A range of areas was targeted in therapy including parent-child interaction work. Working with parents was more popular when the children were younger. Numbers of therapists targeting phonological awareness as well as more traditional aspects of speech and language was noteworthy.

A significant proportion of children was on review and/or on the waiting list, especially at T1. From T1, numbers on the waiting list was negligible. This was not reflected in an increase in children receiving regular therapy. Although there was an increase in discharge rates at T2, the children who were discharged were not generally previously on the waiting list (four children were) or on review (except four children). A waiting list or review policy therefore cannot be interpreted as a strategy of monitoring those with resolving problems.

5.4. The relationship between speech output and developmental measures, psychosocial measures and amount of therapy received

In order to examine the relationships between speech output and measures collected through questionnaire data, Spearman correlations were calculated. A speech output composite was calculated using all speech output tasks for each of the three testing phases. Z-scores were calculated for each group based on each group's mean and SD on the speech composite. Results for the speech disordered group and the control groups are reported separately in Tables 5.8-5.10. For several measures, incidence of occurrence was so low as to preclude analysis. No correlations were calculated for family history because of low reported incidence.

Very few significant correlations were obtained for either group. For the speech disordered group, amount of therapy correlated negatively with speech output skills, i.e. greater intensity of therapy was associated with relatively poor speech. There were significant negative correlations between T1 and T2 speech output and measures of asthma and incidence of coughs and colds, i.e. reported respiratory health problems were associated with poorer speech output skills. There was also a significant negative correlation between reported feeding problems and poorer speech output at T2. No significant relationship was found between parental concern about children's speech and level of speech performance, either at T3 when parental concern was measured, or at T1 or T2 (i.e. earlier level of speech difficulty and parental concern at T3).

For the control group, there was a small significant correlation between speech output at T2 and peer relationships, i.e. higher scores on speech output were associated with having better-reported peer relationships. No correlations were calculated for developmental measures because of relatively low incidence.

Table 5.6.

Therapy data: Average session times and percentage of children by type of therapy

	Up till T1 (total n=45)	T1-T2 (total n=44)	T2-T3 (total n=41)
Age of referral to SLT	2.96 (.91)		
No. of individual sessions	13.93 (26.44)	15.07 (34.16)	7.27 (12.95)
No. of group sessions	14.27 (36.16)	11.40 (33.61)	5.07 (14.87)
Approximate length of individual session	54.27 (19.70)	44.85 (18.93)	42.88 (12.90)
Total no. of minutes of therapy	1136.31 (1761.87)	972.43 (1587.49)	464.18 (786.05)

Note: SDs in parentheses

	Up till T1	T1-T2	T2-T3
	% of children	% of children	% of children
***Type of therapy:**			
Phonological	66.7 (30/45)	57.1 (24/42)	34.1 (14/41)
Oral motor skills	37.8 (17/45)	23.8 (10/42)	9.8 (4/41)
Articulatory	17.8 (8/45)	40.5 (17/42)	34.1 (14/41)
Phonological awareness	48.9 (22/45)	51.2(21/41)	36.6 (15/41)
Expressive language	20 (9/45)	11.9 (5/42)	24.4 (10/41)
Receptive language	15.6 (7/45)	9.5 (4/42)	7.3 (3/41)
Play skills	4.4 (2/45)	0 (0/42)	0 (0/40)
Listening skills	37.8 (17/45)	21.4 (9/42)	12.2 (5/41)
Social skills	6.7 (3/45)	7.1 (3/42)	4.9 (2/41)
Parent workshop	20 (9/45)	0 (0/42)	0 (0/41)
Parent-child interaction	11.1 (5/45)	4.8 (2/42)	0 (0/41)
Other	6.7 (3/45)	11.9 (5/42)	2.4 (1/41)
Therapy setting:			
Clinic	80 (32/40)	69.8 (30/43)	53.7 (22/41)
School	0 (0/40)	2.3 (1/43)	2.4 (1/41)
Language unit	2.5 (1/40)	7 (3/43)	7.3 (3/41)
Hospital	2.5 (1/40)	0 (0/43)	0 (0/41)
Combination of settings	15 (6/40)	6.9 (3/43)	0 (0/41)
Specialist centre	0 (0/40)	0 (0/43)	2.4 (1/41)
Frequency of liaison:			
yearly	23.1 (9/39)	4.9 (2/41)	2.4 (1/41)
termly	5.1 (2/39)	22 (9/41)	24.4 (10/41)
occasionally	33.3 (13/39)	34.1 (14/41)	14.6 (6/41)
none	30.8 (12/39)	29.3 (12/41)	51.2 (21/41)
ongoing	7.7 (3/39)	9.8 (4/41)	7.3 (3/41)
***Management:**			
Regular for therapy	78 (32/41)	75.6 (31/41)	53.7 (22/41)
On review	36.6 (15/41)	24.4 (10/41)	29.3 (12/41)
On waiting list	36.6 (15/41)	7.3 (3/41)	2.4 (1/41)
Planned discharge	0 (0/41)	0 (0/41)	0 (0/41)
Discharged	0 (0/41)	26.2 (11/42)	52.5 (21/40)
Involvement of other agencies	33.3 (14/42)	19 (8/42)	15.4 (6/39)
Statement	9.8 (4/41)	7.1 (3/42)	10.3 (4/39)
Stage 1	0	2.4 (1/42)	5.1 (2/39)
Stage 2	0	4.8 (2/42)	2.6 (1/39)
Stage 3	7.3 (3/41)	4.8 (2/42)	10.3 (4/39)

* not mutually exclusive categories

Table 5.7.

Therapy data: Average session times of children attending clinic at T1

	Up till T1 (total n=32)	T1-T2 (total n=32)	T2-T3 (total n=32)
No. of individual sessions	7.63 (8.29)	6.68 (9.46)	4.69 (6.69)
No. of group sessions	4.97 (6.11)	2.35 (4.04)	1.17 (3.14)
Approximate length of individual session	52.34 (12.89)	47.78 (19.08)	43.61 (9.82)
Total no. of minutes of therapy	650.16 (595.83)	520.18 (490.15)	277.93 (436.91)

Note: SDs in parentheses

Table 5.8.

Spearman Correlations of amount of therapy and psychosocial measures with speech output tasks (Speech disordered group)

	Therapy 1	Therapy 2	Therapy 3	Social class	Hyper activity	Conduct	Emotion	Prosocial	Peer Problems
Output T1	-.28	-.28	-.37[a]	-.22	-.05	-.09	-.11	-.07	-.17
Output T2	-.29	-.29	-.59[c]	-.07	-.22	-.08	-.01	-.1	-.24
Output T3	-.38[a]	-.27	-.65[c]	-.09	-.21	.07	.11	-.17	-.19

[a] $p<.05$ [b] $p<.01$ [c] $p<.001$

Table 5.9.

Spearman Correlations of psychosocial measures with speech output tasks (Control group)

	Social class	Hyperactivity	Conduct	Emotion	Prosocial	Peer Problems
Output T1	-.1	.04	-.20	.08	.08	.18
Output T2	-.08	.08	.003	.14	-.25	.39[a]
Output T3	-.17	.07	-.04	.13	.03	.05

[a] $p<.05$ [b] $p<.01$ [c] $p<.001$

Table 5.10.

Spearman Correlations of developmental measures with speech output tasks (Speech disordered group)

	Birth order	Prematurity	Birth complications	Feeding problems	Coughs & colds	Ear infections	Concern with hearing	Catarrh	Allergies	Asthma
Output T1	-.28	-.27	.25	-.26	-.32[a]	-.13	-.09	-.07	.07	-.32[a]
Output T2	-.20	-.05	.23	-.37[a]	-.45[b]	-.01	-.04	-.17	.04	-.32[a]
Output T3	-.13	-.09	.23	-.29	-.30	.09	-.14	-.01	.16	-.24

	Glasses	Vision	Handedness	Physical	Age of first words	Parents concerns at T3
Output T1	-.09	-.21	.17	-.19	.06	.03
Output T2	-.24	-.19	.17	-.08	-.01	-.07
Output T3	-.34a	-.29	.12	-.08	-.22	-.07

[a] $p<.05$ [b] $p<.01$ [c] $p<.001$

5.5. Discussion

5.5.1. Birth order and developmental history

There was a significantly different distribution of birth order between the two groups, with more later born children in the speech disordered group. Birth order has been weakly associated with speech and language impairment. Shriberg et al. (1994) found a near-significant difference on birth order between children who normalised versus those who did not, but Tomblin (1990) found if language disordered participants and controls were matched on family size and socioeconomic status, birth order effects disappeared. The finding in this cohort is potentially interesting as the groups were similar in their socioeconomic status. Unlike in Tomblin's (1990) study, however, family size was not controlled for and, indeed, the groups differed significantly in family size. Nevertheless, given that the majority of analyses in this chapter failed to find significant differences between groups, this significant result may be worth consideration in future research.

Group differences were noted on some of the questionnaire data examining developmental history. Overall, no differences were noted on birth history and health problems, with one exception. Children with speech difficulties were found to have a higher incidence of coughs and colds. The frequency of coughs and colds, as well as reported incidence of asthma, correlated with speech output skills. The children had no hearing difficulties at the selection stage and were not reported to have any subsequent increased incidence of hearing difficulties compared to the control group. However, the finding on coughs and colds could suggest that some children are more prone to upper respiratory health problems and may be periodically processing auditory input in a different way or have had periods when hearing levels could have been affected. Higher incidence of reported concern over vision is a surprising result. However, the majority in both groups showed no visual problems and no differences were found on current problems with vision.

As could be predicted, parental concern over speech and language development was greater in the speech disordered group. However, over half of the parents (55%) of children in the speech disordered group were no longer concerned about speech at T3.

This reflects a similar percentage of children who had been discharged from therapy by T3 (53%). Both therapist and parental judgement can determine whether a child is discharged. Therapists will advise parents about the need for future therapy. Many parents will also make such judgements without consultation. They will not bring their children to further appointments or pursue further therapy if they are no longer concerned about their children's speech. Also, if the child is not considered to need regular therapy and is placed on long-term review, it is more likely that parents will decide not to take up these appointments when they arise. Anecdotal evidence for this was noted when discussing the children's speech and language therapy management with families before testing phases at T2 and/or T3. Subtle speech difficulties that were evident at T3 in the majority of children in the speech disordered group are described in Chapter 7 (where 72% of the group were classified as having persisting speech difficulties at T3). These difficulties, however, were not felt to be functionally significant by parents, given the result recorded from the questionnaire. Additionally, no relationship was found between parental concern about speech and actual level of speech at T3.

The speech disordered group was reported to be later in saying their first words than the control group by an average of approximately eight months. Not all studies have found a substantially increased incidence of speech, language or reading difficulties in late talkers (Paul, Murray, Clancy & Andrews, 1997). However, there is some evidence from longitudinal studies of late talkers that they are at increased risk of later language difficulties (Rescorla & Schwartz, 1990) and delayed phonology (Paul & Jennings, 1992; Mirak & Rescorla, 1998). The results from this cohort support the latter finding of an association between late talkers and delayed speech development.

5.5.2. Family history of speech/literacy difficulties

There was a very high reported incidence of the speech disordered group's siblings having speech and/or literacy difficulties (44.7%) compared to the control group's siblings (11%). This suggests a possible familial factor in these children's speech difficulties, although it was also noted that children with speech difficulties have more siblings than controls. No evidence was found to support a familial influence through the parents and their families. Reported family history of speech/literacy difficulties in both parents and their families was not significantly different between groups, although there was a nonsignificant trend towards a slightly higher incidence of reading difficulties on the mother's side.

5.5.3. Psychosocial skills

Children with speech difficulties did not score less well on measures of psychosocial behaviour compared to controls, as measured at T3, by teacher rating of the Strengths and Difficulties Questionnaire (1997). Thus, there was no indication of difficulties in this area, contrary to findings by Cantwell and Baker (1987). However, as many of these children's speech difficulties had shown dramatic improvement by T3 when the rating was made, caution must be exercised in interpreting data collected at this stage.

5.5.4. Therapy provision

Variability was noted in type and amount of therapy provision of children with speech difficulties. This could be predicted given the range of difficulty present in the group, as well as the changing needs of the group during the course of the study. As would be expected, phonological therapy was the most frequent type of therapy received (at T1 and T2). Many clinicians also reported giving phonological awareness therapy, reflecting an increasing awareness in the profession of the importance of this skill. A small proportion of the sample attended language units, whilst the vast majority attended a clinic setting for their therapy. Over the course of each year, the same child could have various management strategies: i.e. a child could be seen for regular therapy interspersed with periods on a waiting list or on review. Others might be receiving daily help within a language unit. For those in community clinics, children were receiving an average of less than eight sessions of individual therapy at each time phase (1^{st} referral-T1, T1-T2, T2-T3). By T2, 26% of the sample had been discharged from therapy; and, by T3, this figure had risen to over half of the group, 53%.

Amount of therapy correlated negatively with speech output skills, i.e. the better the level of speech skill, the less therapy was received. This would reflect an appropriate allocation of resources towards those children with the most severe speech difficulties. The result does not show a positive effect of intervention on speech skills. However, since intervention varied freely, with no systematic control or design over what children received, this data does not address directly issues of efficacy or effectiveness of therapy. For example, one cannot address the issue of intensity of therapy. Children who received intensive or less intensive therapy (e.g. attendance at a language unit or specialist centre) differed in their level of speech/language difficulty, so one cannot compare the effect of intensity on speech skills if levels of difficulty are not comparable.

5.5.5. Caveat

These findings need to be qualified because of the prediction of heterogeneity and the possibility that subgroups exist. The selection procedure was designed to recruit a fairly homogeneous sample. All children in the speech disordered group were within a quite narrow age band. They were required to have significant speech difficulties on a standardised speech assessment, had no current hearing loss, were of normal nonverbal intelligence and were carefully matched to controls on the basis of age, nonverbal intelligence and school environment. However, it could be argued that the group was simply too mixed or the number of participants too small to assess accurately some of these questions, particularly epidemiological variables. Certainly, due to small incidence of certain measures, Chi-square and correlational analysis was not appropriate. Where measures did not differentiate the speech disordered group and the control group, they might differentiate certain types or subgroups of children with speech difficulties. Considerable heterogeneity was noted in terms of speech severity, speech input difficulties and additional language impairment and there was also a range of outcome. It could therefore be hypothesised that there is a relationship between some of the measures and differing performance on other measures. Heterogeneity is specifically addressed in the next chapter, Chapter 6. This questionnaire data will also be analysed further in Chapter 7, where analysis by speech outcome is conducted.

Chapter 6
Exploring heterogeneity

6.1. Introduction

Chapter 4 described pervasive differences between the speech disordered group and their matched controls. It was predicted that considerable variation in performance would be found within the speech disordered group, as indicated by other studies of children with speech difficulties (Paul & Shriberg, 1982; Lewis, Ekelman & Aram, 1989; St. Louis, Ruscello & Lundeen, 1992; Shriberg et al., 1999; Lewis, Freebairn & Taylor, 2000). Variability in speech profile is observed to be one of the major theoretical challenges in describing the nature of developmental speech disorder (Dodd, 1995; Stackhouse & Wells, 1997).

This chapter therefore explores the heterogeneity of the speech disordered group by examining the range of performance on the test battery. It has been suggested that much of the heterogeneity of this population at least in terms of tracking the developmental course of the disorder, is accounted for by the additional, varying language difficulties that can be associated with speech difficulties. Findings show differing profiles in speech, language and literacy relative to language ability (Hall & Tomblin, 1978; Bishop & Edmundson, 1987a). Studies using a subgroup design, that classified children according to presence or absence of language problems, have not been clear-cut in differentiating phonological awareness performance (Leitao et al., 1997) and literacy skill (Bird et al., 1995). However, a follow-up study that directly compared children with isolated speech difficulties and children with speech and language difficulties reported better language and reading outcomes for those with only speech difficulties at age 8/9 (Lewis et al., 2000a). They also reported differences at follow-up on tests of multisyllabic word repetition, nonword repetition and language measures. In this chapter, a similar classification is used to explore differences relative to language ability. Through a matched control comparison, it will also be possible to examine differences relative to normal development. The role of input skills will also be examined within the subgroup analysis, an area not addressed in previous research.

Thus subgroup analysis is reported which categorised the group into those with only speech difficulties at T1 and those with speech and language difficulties at T1. The longitudinal dataset also gave an opportunity to explore the stability of this subgrouping over time. Subgrouping, which requires somewhat arbitrary cut-off points, has been found to be an imperfect way of identifying stable patterns of performance over time in classifying children with speech/language problems (Bishop & Edmundson, 1987a) and subtypes associated with SLI (Conti-Ramsden & Botting, 1999). This chapter considers whether subgrouping is a reasonable way of accounting for the variation in performance of children with primary speech difficulties and whether the defining element of the subgrouping, i.e. language skill, continues to differentiate the two subgroups over time.

6.1.1. Research questions

1. What is the range of performance of the speech disordered group on measures of speech output, speech input and language?
2. Do children classified with speech and language difficulties at age 4 perform differently from children classified with specific speech difficulties on tests of speech output and tests of speech input?
3. Do children identified with additional language difficulties at age 4 continue to have persisting speech and/or language difficulties at ages 5 and 6?

6.2. Results

6.2.1. Range of speech severity, language difficulty and speech input difficulties

Examination of the SDs of the speech disordered group and control group on the test battery (Tables 4.1-4.3, Chapter 4) showed a similar deviation for each group, except for the speech output tasks. On these measures, the speech disordered group showed greater deviation. This is clearly illustrated in the Box Plots (Figures 6.1-6.3) showing the full range of scores at each main testing phase for each main composite of speech output, speech input, expressive and receptive language. Composites were as follows:

Speech output:

T1: Word repetition, nonword repetition, articulatory naming

T2: Word repetition, nonword repetition, articulatory naming, LF word repetition, LF nonword repetition

T3: Articulatory naming, LF word repetition, LF nonword repetition

Speech input:

T1 and T2: AD: picture, AD: same/different and AD: ABX.

T3: AD: picture II and AD: ABX.

Expressive language:

T1, T2, T3: Bus Story (information and MLU score), RAPT (information and grammar score), Naming.

Receptive language:

T1, T2, T3: TROG, BPVS.

Controls' means and SDs were used for calculating a z-score for each composite. The Box Plots illustrate that there is no overlap at T1 on speech output tasks between the two groups, but, by T3, with significant improvement by the speech disordered group and some children now with resolved speech, overlap occurs. Despite similar SDs on the language and speech input measures, it was apparent that there was considerable heterogeneity of performance on these measures for the speech disordered group in terms of whether children displayed deficits or not. Some children had difficulty on some measures, whilst others performed within normal limits (illustrated by overlap between boxes on the Box Plot at each testing phase). This heterogeneity was explored further through examination of range of performance.

Figure 6.1.
Box Plot of composite scores at T1 by group

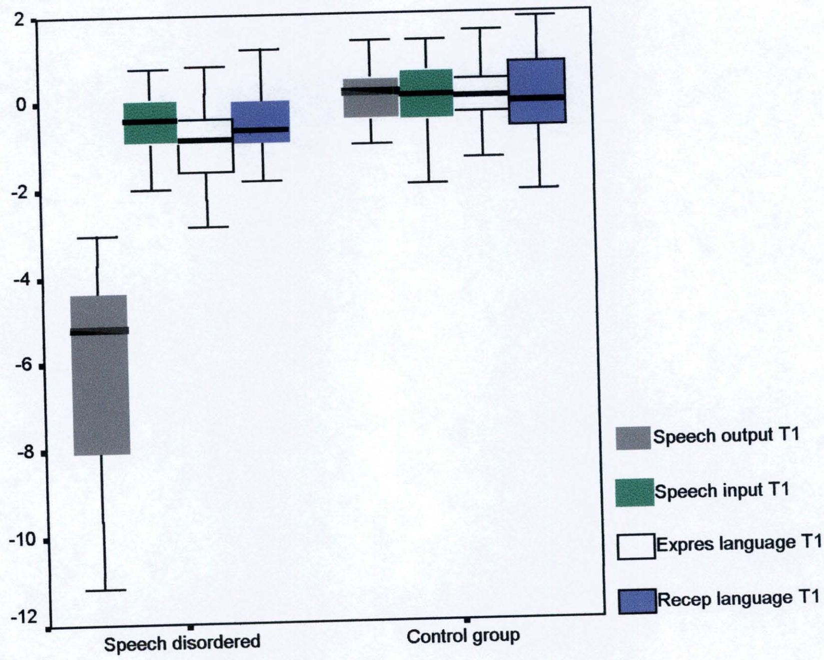


Figure 6.2.
Box Plot of composite scores at T2 by group

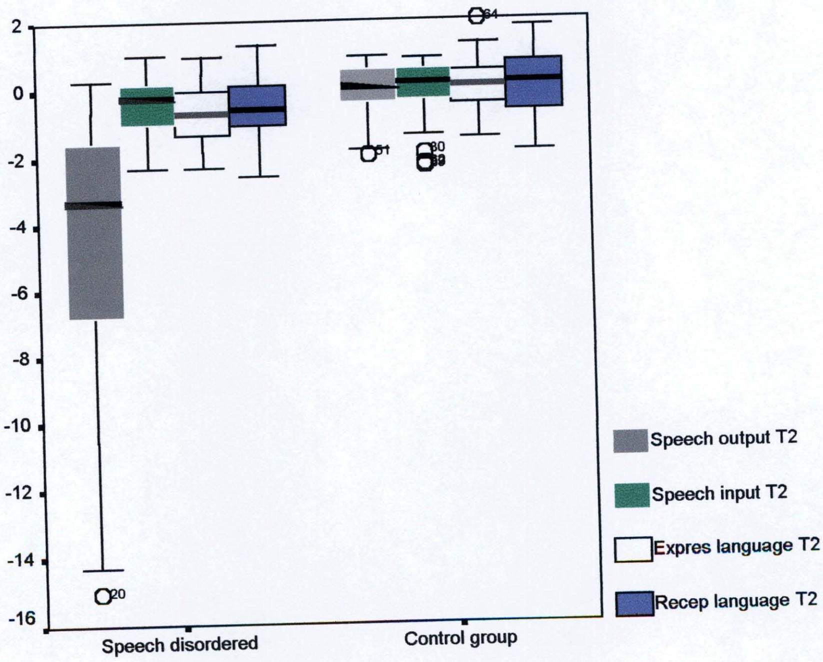
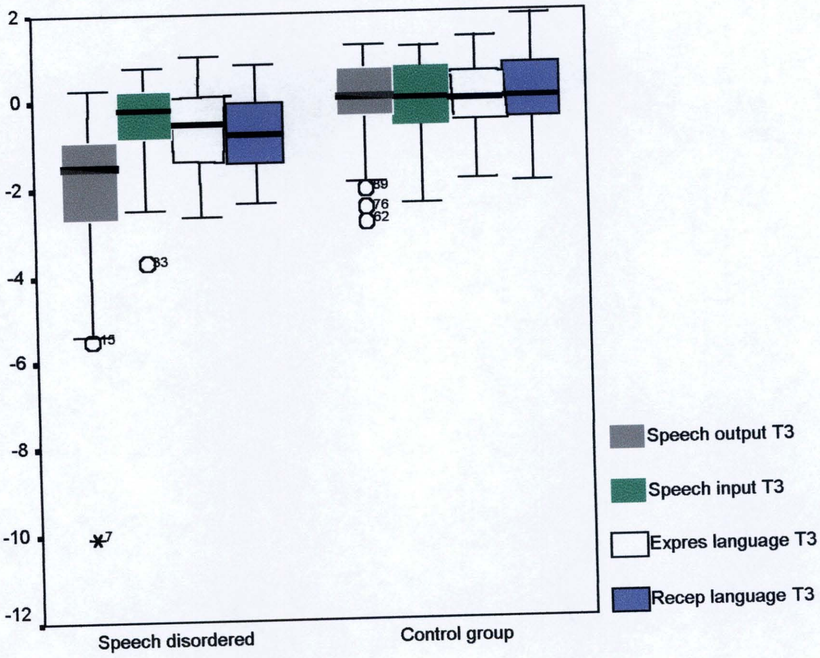


Figure 6.3.
Box Plot of composite scores at T3 by group



6.2.1.*1*. Speech Severity

Table 6.1 shows the range of speech difficulties according to the speech output composites at each testing phase and Table 6.2 shows the range for individual tests. For the composite measure at T1, five controls scored between -1 and -3 SDs below the mean of the entire control group. However, there is no overlap between them and the speech disordered group: all children in the speech disordered group have z-scores below –3 and these range from –3 to –12 SDs. Therefore, although some children in the control group show low performance on speech output tasks, the two groups are statistically distinct in their speech performance at the outset of the study. This incidence has no impact on the subsequent analyses: indeed, excluding the five controls with the lowest speech scores did not alter the results. At T2, seven children with speech difficulties are now performing within normal limits. While at T1 no children with speech difficulties scored above –3, at T2, nearly 30% are scoring between –1 and –3. However, there is still quite a large spread of scores. At T3, 13 (27.7%) children with speech difficulties are performing within I SD and 25 (53%) within 1.5 SDs of the controls' mean. Except for one child with a very severe and persisting speech difficulty, all the other children are scoring in the range -1 to -6 (with over half scoring between –1 and -3).

Table 6.1.
Ranges of speech difficulties of the Speech disordered group at T1, T2 and T3

	T1	T2	T3
Range (composite Z-score)	% (n)	% (n)	% (n)
Above -1	0 (0)	14.9 (7)	27.7 (13)
-1 - -2	0 (0)	12.8 (6)	31.9 (15)
-2 - -3	0 (0)	17 (8)	19.1 (9)
-3 - -9	83 (39)	36.2 (17)	19.1 (9)
-9 +	17 (8)	19.1 (9)	2.1 (1)

Note: (n) = number of children

Table 6.2.
Ranges of speech difficulties of the Speech disordered group at T1, T2 and T3 by speech output task

	T1			T2					T3		
	WRep	NWrep	AName	WRep	NWrep	AName	LFWRep	LFNWRep	LFWRep	LFNWRep	AName
Range (Z-score)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
Above -1	0 (0)	0 (0)	4.3 (2)	27.7 (13)	25.5 (12)	19.1 (9)	19.1 (9)	19.1 (9)	40.4 (19)	31.9 (15)	31.9 (15)
-1 - -2	0 (0)	0 (0)	12.8 (6)	0 (0)	4.3 (2)	4.3 (2)	12.8 (6)	23.4 (11)	21.3 (10)	19.1 (9)	29.8 (14)
-2 - -3	0 (0)	0 (0)	19.1 (9)	8.5 (4)	14.9 (7)	12.8 (6)	12.8 (6)	21.3 (10)	10.6 (5)	29.8 (14)	14.9 (7)
-3 - -9	61.7 (29)	63.8 (30)	63.8 (30)	29.8 (14)	40.4 (19)	46.8 (22)	46.8 (22)	36.2 (17)	25.5 (12)	19.1 (9)	21.3 (10)
-9 +	38.3 (18)	36.2 (17)	0 (0)	34 (16)	14.9 (7)	17 (8)	8.5 (4)	0 (0)	2.1 (1)	0 (0)	(1)

Note: (n) = number of children

Key: Wrep= Word repetition (pcc), Nwrep= Nonword repetition (pcc), Aname = Articulatory naming (pcc), LFWRep = LF word repetition (pcc), LFNWRep = LF nonword repetition (pcc)

6.2.1.2. Speech input deficits

The proportion of children with speech difficulties who also had speech input difficulties was calculated. Using z-scores calculated from the control data, children were classified as having speech input difficulties if they scored below –1 SD on each speech input task and on the composite measure, as reported in Table 6.3.

Seven controls scored between -1 and -3 SDs on the T1 composite. Five controls scored between -1 and -2 SDs on the T2 and T3 composite. According to the speech input composite, most of the speech disordered group scored within normal limits (between 70-90% of the group, depending on the testing phase). Compared to the speech output tasks, there is much less change over time and much more stability across tasks. Where deficits are noted, these are much less extreme than those noted in the speech output tasks.

Analyses using each speech input task revealed a different proportion of children showing difficulties. The percentage of children showing deficits on each speech input measure at each testing phase is shown in Table 6.4. At T1, approximately a third of the group showed difficulties on the AD: picture task (36.2%) and the AD: same/different task (31.9%). The proportion of children with deficits on the AD: ABX task was smaller (15.9%) due to the chance effects found in the control group (and as discussed in Chapter 4). At T2, a similar proportion of the group showed deficits on the AD: picture task and the AD: same/different task, and the proportion of children with deficits on the AD: ABX task had increased from 15.9% to 21.3%. At T3, there was a shift in the pattern of deficit, with a smaller proportion showing deficits on the AD: picture task (only 19%), whilst nearly 40% had difficulties on the AD: ABX task. These differences in pattern of deficits reflect the differing task sensitivity of these measures, as discussed in more detail in Chapter 4. Lack of stability was thus noted across tasks and over time, with very few children showing a consistent deficit on any one task over two or three testing phases. However, overall, the numbers of children showing low performance at some point in time on a speech input measure was high, and considerably higher than the composite measure of speech input revealed.

6.2.1.3. Language deficits

Proportion of additional language difficulties in the group was calculated in a similar way to the examination of speech input skills. First, a composite of language measures (Bus Story (information and MLU score), RAPT (information and grammar score), Naming, TROG, BPVS) was used to calculate the incidence of language difficulty at each testing phase (reported in Table 6.3). Unlike the speech development of these children, the language skills of the group remain relatively stable over time with the incidence of age-appropriate language skills increasing from 56.5% to 63.8%. Four controls scored between –1 and –2 SDs below the mean.

Second, the proportion of children with speech difficulties who had additional language difficulties was calculated for each language task separately (see Table 6.5). This shows a much higher proportion of children with difficulties than the proportion when using a composite measure. It also reveals difficulties with both expressive and receptive language tasks. Difficulties with expressive language tasks (excluding Naming) decrease between T1 and T2 and then remain relatively stable between T2 and T3. Poor performance on the RAPT (grammar score) appears to be proportionately greater than poor performance on the other expressive language tasks. Problems on the Naming task increase between T1 and T2, and then decrease slightly between T2 and T3. In contrast, difficulties with receptive grammar remain fairly stable over all three testing phases and problems with receptive vocabulary, whilst decreasing between T1 and T2, then show an increase between T2 and T3. Table 6.6 shows the percentage of children showing difficulty on any receptive language measure or expressive language measure. This also shows larger numbers of children showing some level of difficulty with these tasks.

Table 6.3.

Range of language and speech input skills of the Speech disordered group at T1, T2 and T3

	T1		T2		T3	
Range (composite z-score)	% language* (n)	% input** (n)	% language* (n)	% input (n)	% language (n)	% input* (n)
Above -1	56.5 (26)	75 (33)	58.7 (27)	70.2 (34)	63.8 (29)	80.4 (37)
-1 - -2	39.1 (18)	25 (11)	34.8 (16)	14.9 (7)	34.04 (16)	15.2 (7)
-2 - -3	4.35 (2)	0 (0)	6.38 (3)	12.8 (6)	2.13 (1)	2.2 (1)
-3 - -4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2.2 (1)

Note 1: z-scores of *d'* calculations used for speech input tasks

Note 2: (n) = number of children

* out of total n= 46 (missing data)

** out of total n= 44 (missing data)

Table 6.4.

Percentage of the Speech disordered group showing deficits on the 3 speech input tasks

	%-1 SD on AD: Pic (n)	% -1 SD on AD: ABX (n)	% -1 SD on AD: S/D (n)	% -1 SD on any one of the tasks (n)
T1	36.2 (17)	15.9 (7)*	31.9 (15)	55.3 (26)
T2	38.3 (18)	21.3 (10)	34 (16)	51.1 (24)
T3	19.2 (9)	39.1 (18)**	-	48.9 (23)
T1 and T2	21.3 (10)	6.8 (4)*	21.3 (10)	66 (31)
T2 and T3	10.6 (5)	17 (7)**	-	68.1 (32)
T1, T2 and T3	6.5 (3)	4.3 (2)**	-	76.6 (36)

Note 1: z-scores of *d'* calculations used

Note 2: (n) = number of children

* out of total n= 44 (missing data)

** out of total n= 46 (missing data)

Key: AD: Pic = AD: picture task, AD: ABX = AD: ABX, AD: S/D = AD: same/different

Table 6.5.
Percentage of children showing deficits on the language measures

	Bus information score	Bus MLU score	RAPT information score	RAPT grammar score	Naming	BPVS	TROG
	% -1 SD (n)	% -1 SD (n)	% -1 SD (n)	% -1 SD (n)	% -1 SD (n)	% -1 SD (n)	% -1 SD (n)
T1	40.4 (19)	59.6 (28)	31.9 (15)	66 (31)	34 (16)	42.6 (20)	26.1 (12)*
T2	37 (17)*	39.1 (18)*	21.3 (10)	53.2 (25)	48.9 (23)	29.8 (14)	29.8 (14)
T3	31.9 (15)	34 (16)	23.4 (11)	40.4 (19)	40.4 (19)	55.3 (26)	27.7 (13)
T1-T2	28.3 (13)*	37 (17)*	17.02 (8)	46.8 (22)	27.7 (13)	25.5 (12)	13.04 (6)*
T2-T3	21.7 (10)*	21.7 (10)*	10.6 (5)	25.5 (12)	36.2 (17)	27.7 (13)	17.4 (8)
T1-T2-T3	19.6 (9)*	21.7 (10)*	6.4 (3)	23.4 (11)	25.5 (12)	25.5 (12)	10.9 (5)*

Note 1: (n) = number of children
* n=46 (missing data)

Table 6.6.
Percentage of children showing deficits on any of the language measures

	Either receptive language measure	Any expressive language measure
	% -1 SD (n)	% -1 SD (n)
T1	52.2 (24)	78.7 (37)
T2	44.7 (21)	74.5 (35)
T3	59.6 (28)	68.1 (32)
T1-T2	61.7 (29)	85.1 (40)
T2-T3	66 (31)	80.9 (38)
T1-T2-T3	68.1 (32)	89.4 (42)

Note 1: (n) = number of children

6.2.2. Speech/Language Subgroup analyses

It is possible that there are differentiable subgroups underlying the variation reported. One common way of subgrouping this population is by the presence of additional language difficulties. In order to replicate this work, and to attempt to explain the heterogeneous data, subgroup analysis was carried out. To investigate whether children with speech difficulties differed from those with speech and language difficulties, a prospective analysis was conducted with classification of the sample into two subgroups at T1: a Speech-only subgroup and a Speech and language subgroup. The performance of the two subgroups and their matched control groups was then compared over the three testing phases, T1, T2 and T3. The following criterion for additional language impairment was set: a child was regarded as having a language difficulty if they gained a score at or below the 10th centile on two or more of the 7 language measures (which could be receptive and/or expressive). This was slightly more stringent than Bird et al.'s (1995) classification level of below the 10^{th} centile on at least one measure of expressive or receptive language. In order not to falsely classify children as having additional language difficulties, children were required to score below normal limits on two or more tests to be assigned to the speech and language subgroup. Nineteen children (40.4%) had additional language difficulties, leaving 28 children (59.6%) in the speech-only group. This figure is broadly in line with that reported in Table 6.3, where a total of 43.5% were scoring below –1 SD on a composite measure. Eleven of the children with both speech and language difficulties had deficits in both expressive and receptive language while 8 had expressive language problems alone.

To assess the performance of the two clinical subgroups on speech processing measures, multivariate analyses of variance were conducted at each point in time. There were two between-subjects factors: Group (Speech disordered versus Control) and Subgroup (Speech-only impaired children and their matched controls versus Speech and language impaired children and their matched controls). This analysis had the advantage of being able to compare matched pairs. Some of the variables at T1 were excessively skewed, usually due to a floor effect. Transformations did not ameliorate the distributions. Raw scores (or *d'* scores for the speech input tasks) were used in all calculations. Means and SDs, together with univariate statistics are reported in Tables 6.7 and 6.8. Where there was a significant interaction of Group x Subgroup on a particular univariate measure, simple effects were calculated and are reported in the text and plotted on Bar Charts.

6.2.2.1. Speech processing measures

T1: There was a significant overall effect of Group ($F(6,81) = 77.71$, $p<.001$) and of Subgroup ($F(6,81) = 5.94$, $p<.001$) as well as a significant interaction between Group and Subgroup ($F(6,81) = 3.41$, $p<.01$). Univariate analyses indicated that the clinical subgroups performed less well than controls on all of the speech processing tasks except for AD: ABX and AD: same/different. There were significant Subgroup differences on all the speech output tasks (Word repetition, Nonword repetition and Articulatory naming) and on the AD: picture task indicating that children with speech and language impairments and their matched controls performed less well than those with speech-only difficulties and their matched controls. There were also significant interactions on the three speech output tasks and the AD: picture task.

Tests of simple effects were calculated to explore these significant interactions. These are plotted in Figures 6.4-6.7. These revealed that children with speech and language difficulties performed significantly less well than children with speech-only difficulties on two tasks: AD: picture task ($F(1, 87) = 10.59$, $p<.005$) and Articulatory naming ($F(1,87) = 4.48$, $p<.05$). There were no significant differences on word repetition ($F(1,87) = 1.83$, ns) and nonword repetition ($F(1,87) = 1.99$, ns). Although the speech and language impaired children did not perform significantly less well than the speech-only children on the repetition tasks, means suggest that differences may be emerging. Children with speech-only impairment performed no differently to their controls on AD: picture task ($F(1, 87) = .56$, ns) but were scoring less well on the three speech tasks (Word repetition: $F(1,87) = 133.05$, $p<.001$; Nonword repetition: $F(1,87) = 141.97$, $p<.001$; Articulatory naming: $F(1,87) = 66.36$, $p<.001$). Children with speech and language difficulties performed significantly less well than their controls on all tasks where there was a significant interaction on the univariate analysis (i.e. Word repetition:

F (1,87) = 174.91, p<.001; Nonword repetition: F (1,87) = 179.40, p<.001; Articulatory naming: F (1,87) = 108.18, p<.001; and AD: picture: F (1,87) = 11.44, p<.001). Children in Control subgroup 2 were less skilled than children in Control subgroup 1 on the speech output measures (Word repetition: F (1,87) = 4.51, p<.05; Nonword repetition: F (1,87) = 5.30, p<.05; Articulatory naming: F (1, 87) = 5.06, p<.05). However, these differences are relatively small. No significant difference was found between control subgroups on the AD: picture task (F (1,87) = 1.49, ns).

T2: There was a significant overall effect of Group (F (8,82) = 13.11, p<.001) and of Subgroup (F (8,82) = 4.18, p<.001) as well as a significant interaction between Group and Subgroup (F (8,82) = 4.08, p<.01). Univariate analyses indicated that the clinical subgroups performed less well than the controls on all of the speech output tasks (including the two extension repetition tasks) and on two measures of speech input: AD: ABX task and on AD: picture, (no significant difference on AD: same/different). There were significant Subgroup differences on all of the speech output tasks (Word repetition, Nonword repetition, Articulatory naming, LF word repetition and LF nonword repetition) and AD: same/different and AD: picture task. This indicated that children with speech and language impairments and their controls performed less well than those with speech-only difficulties and their controls. There were also significant interactions on the univariate analysis between Group x Subgroup on the five speech output measures.

Tests of simple effects were calculated on these significant interactions. These are illustrated in Figures 6.8-6.12. These revealed that children with speech and language difficulties performed significantly less well than children with speech-only difficulties on all speech output tasks (Word repetition: F (1,90) = 16.17, p<.001; Nonword repetition: F (1,90) = 9.38, p<.005; Articulatory naming: F (1, 90) = 8.82, p<.005; LF word repetition: F (1,90) = 11.37, p<.001; and LF nonword repetition: F (1,90) = 7.64, p<.01). Although the interaction between Group and Subgroup failed to reach significance on the speech input tasks, means on these three measures indicate that the speech and language impaired subgroup was performing less well than the speech-only subgroup who performed similarly to the control group. Children with speech difficulties were still performing significantly less well than their controls on these speech output tasks (Word repetition: $F(1,90) = 9.32$, $p<.005$; Nonword repetition: $F(1,90) = 15.53$, $p<.001$; Articulatory naming: $F(1, 90) = 20.63$, $p<.001$; LF word repetition: $F(1,90) = 20.65$, $p<.001$; and LF nonword repetition: $F(1,90) = 27.20$, $p<.01$). Children with speech/language difficulties also scored significantly less well than their controls: (Word repetition: $F(1,90) = 58.89$, $p<.001$; Nonword repetition: $F(1,90) = 44.38$, $p<.001$; Articulatory naming: $F(1, 90) = 53.55$, $p<.001$; LF word repetition: $F(1,90) = 60.74$, $p<.001$; and LF nonword repetition: $F(1,90) = 53.43$, $p<.001$). Children in Control subgroup 2 performed significantly less well than Control subgroup 1 on all speech output measures except for Word repetition (Word repetition: $F(1,90) = 2.1$, ns; Nonword repetition: $F(1,90) = 4.02$, $p<.05$; Articulatory naming: $F(1, 90) = 4.17$, $p<.05$; LF word repetition: $F(1,90) = 4.59$, $p<.05$; and LF nonword repetition: $F(1,90) = 5.94$, $p<.05$).

T3: There was a significant overall effect of Group ($F(5,81) = 12.46$, $p<.001$) and of Subgroup ($F(5,81) = 4.24$, $p<.01$) but no significant interaction between Group and Subgroup ($F(5,81) = 1.94$, ns). Univariate analyses showed that the groups continued to differ on all of the speech output tasks and on AD: ABX task. There were significant Subgroup differences on all tasks indicating that children with speech and language impairments and their controls performed significantly less well than those with speech-only difficulties and their controls. Despite no overall significant interaction, univariate analyses showed significant interactions on the following tasks: AD: ABX task, LF word repetition and LF nonword repetition. In order to see whether the previous patterns of difference were replicated, these interactions were explored using simple effects. These are illustrated in Figures 6.13-6.15. Children with speech and language difficulties performed less well than children with speech-only difficulties on the two repetition tasks (LF word repetition: $F(1, 86) = 10.37$, $p<.005$; LF nonword repetition: $F(1,86) = 6.97$, $p<.01$) as well as the AD: ABX task ($F(1, 86) = 10.70$, $p<.005$). In addition, children with speech-only difficulties performed no differently to the control group on this measure ($F(1,86) = .83$, ns), though they still scored significantly less well on the speech output tasks (LF word repetition: $F(1, 86) = 7.87$, $p<.01$; LF nonword repetition: $F(1,86) = 13.20$, $p<.001$). Children with speech/language difficulties scored less well than their controls on all three measures (LF word repetition: $F(1, 86) = 28.53$, $p<.001$; LF nonword repetition: $F(1,86) = 31.34$, $p<.001$; and AD: ABX task ($F(1, 86) = 13.29$, $p<.001$). There were also no significant differences between the two control groups (LF word repetition: $F(1, 86) = 3.07$, ns; LF nonword repetition: $F(1,86) = 3.28$, ns; and AD: ABX task ($F(1, 86) = 1.23$, ns).

Table 6.7.

Mean performance of the Clinical Subgroups and Controls on tests of speech processing

	Speech-only	Control 1	Speech/ language	Control 2	Between Ss (Group)		Between Ss (Subgroup)		Group x Subgroup	
T1					F (1,86)	MSE	F (1,86)	MSE	F (1,86)	MSE
WRep	57.42 (13.53)$_a$	93.46 (5.30)	37.32 (14.75)$_a$	91.77 (5.76)	377.25^c	108.70	23.18^c	108.70	15.67^c	108.70
NWRep	56.08 (11.56)$_a$	91.36 (4.99)$_b$	36.77 (14.05)$_a$	88.84 (6.48)$_b$	413.53^c	93.16	28.99^c	93.16	15.62^c	93.14
AName	59.88 (13.6)	90.25 (10.4)	37.73 (15.5)	86.72 (8.59)	218.73^c	144.49	26.04^c	144.49	14.37^c	144.49
AD: Pic	42.04 (4.65)$_a$	42.97 (4.36)$_a$	35.39 (6.2)	42.89 (4.43)$_a$	10.12^b	.78	9.92^b	.78	5.51^a	.78
AD: ABX	7.07 (2.07)	8.03 (2.2)	6.71 (2.39)	7.61 (1.69)	1.77	1.4	1.3	1.41	.005	1.41
AD: S/D	14.8 (4.0)	16.7 (3.00)	12.8 (3.6)	14.5 (4.0)	3.74	2.38	5.15^a	2.38	.05	2.38
T2					F (1,89)	MSE	F (1,89)	MSE	F (1,89)	MSE
WRep	88.27 (11.54)	98.52 (2.37)$_a$	65.41 (22.23)	98.20 (2.28)$_a$	70.96^c	142.96	20.10^c	142.96	19.57^c	142.57
NWRep	82.37 (13.42)	96.51 (4.89)	63.16 (22.06)	93.65 (5.08)	64.47^c	165.31	16.43^c	165.31	8.48^b	165.31
AName	80.96 (12.13)	95.03 (3.29)	63.55 (19.0)	93.07 (4.57)	81.46^c	124.72	17.50^c	124.72	9.52^b	124.72
LFWRep	74.77 (15.46)	92.09 (6.03)	50.96 (20.42)	88.89 (6.60)	92.97^c	176.42	22.99^c	176.42	12.67^c	176.42
LFNWRep	66.64 (13.0)	85.03 (7.90)	47.60 (18.43)	80.17 (9.20)	91.48^c	154.76	20.08^c	154.76	7.03^b	154.76
AD: Pic	45.46 (2.22)	46.1 (3.66)	42.37 (4.49)	44.71 (4.06)	5.56^a	.70	5.25^a	.70	.05	.70
AD: ABX	17.07 (3.35)	17.86 (3.72)	14.37 (3.95)	18.06 (3.19)	4.48^a	1.21	2.95	1.21	2.21	1.21
AD: S/D	17.89 (2.12)	18.76 (1.96)	16.33 (3.41)	17.38 (2.25)	1.04	.82	13.16^c	.81	1.27	.82
T3					F (1,85)	MSE	F (1,85)	MSE	F (1,85)	MSE
AName	86.87 (6.55)	94.94 (4.40)	78.47 (14.09)	92.50 (5.30)	38.59^c	62.29	12.46^c	62.29	3.26	62.28
LFWRep	85.41 (8.14)	93.48 (5.25)$_a$	73.29 (15.90)	91.11 (6.33)$_a$	39.66^c	85.81	16.08^c	85.81	5.62^a	85.81
LFNWRep	74.81 (10.89)	87.28 (7.62)$_a$	61.23 (15.85)	83.33 (9.80)$_a$	49.08^c	126.28	13.69^c	126.28	4.06^a	126.28
AD: Pic II	19.07 (.9)	19.23 (1.03)	18.79 (1.13)	18.72 (1.18)	.03	.16	2.69	.16	.15	.16
AD: ABX	19.67 (2.5)$_a$	20.46 (2.73)$_a$	16.68 (2.89)	20.44 (2.09)$_b$	12.12^c	.50	9.88^b	.50	4.92^a	.50

Superscript: $^a p<.05$; $^b p<.01$; $^c p<.001$ Note 1: SDs in parentheses

Note 2: Significant interactions were explored using simple effects: where these calculations were made and the subgroups did not differ significantly the same subscript is used.

Note3: AD: picture, AD: same/different and AD: ABX: raw scores are reported, although d' was used for the calculations

Key

WRep	Word repetition (pcc)	AD: picture	Auditory discrimination (Picture) (Max=48)
NWRep	Nonword repetition (pcc)	AD: ABX	Auditory discrimination (ABX) (Max at T1=12, at T2 and T3=24)
AName	Articulatory naming (pcc)	AD: S/D	Auditory discrimination (same/different) (Max=20)
LFWRep	Low Frequency word repetition (pcc)	AD: pictureII	Auditory discrimination (Picture) (extension) (Max=20)
LFNWRep	Low Frequency nonword repetition (pcc)		

Figure 6.4.
Bar Chart of subgroup differences:
Word repetition task at T1

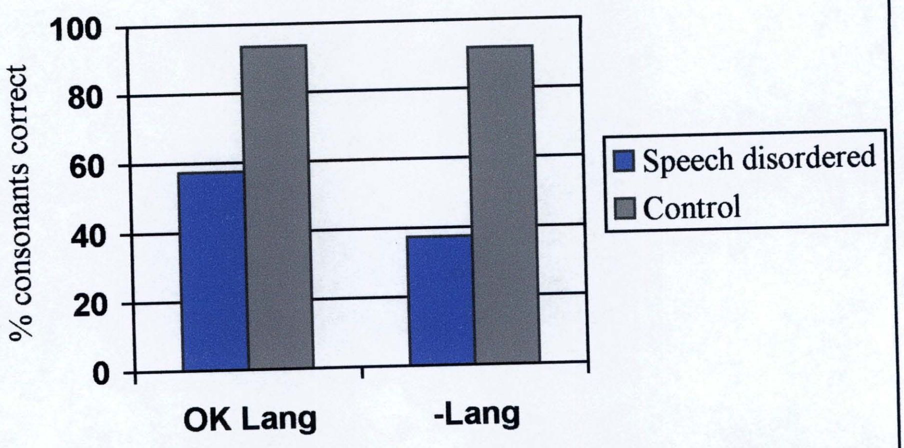


Figure 6.5.
Bar Chart of subgroup differences: Nonword repetition task at T1

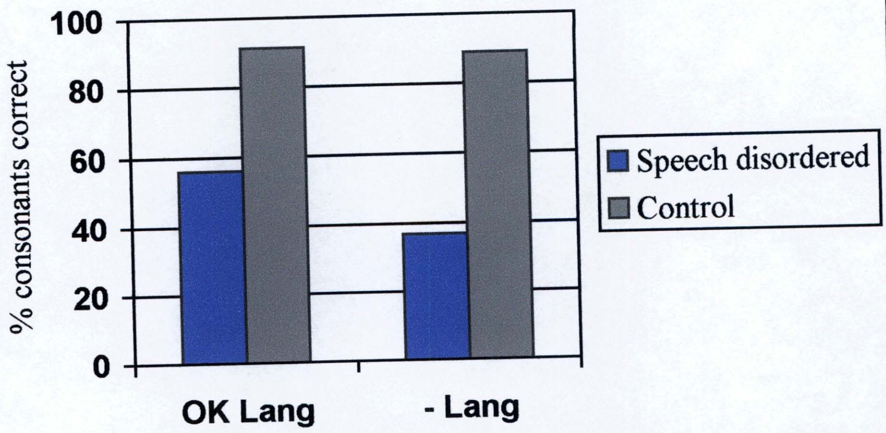


Figure 6.6.
Bar Chart of subgroup differences: Articulatory naming task at T1

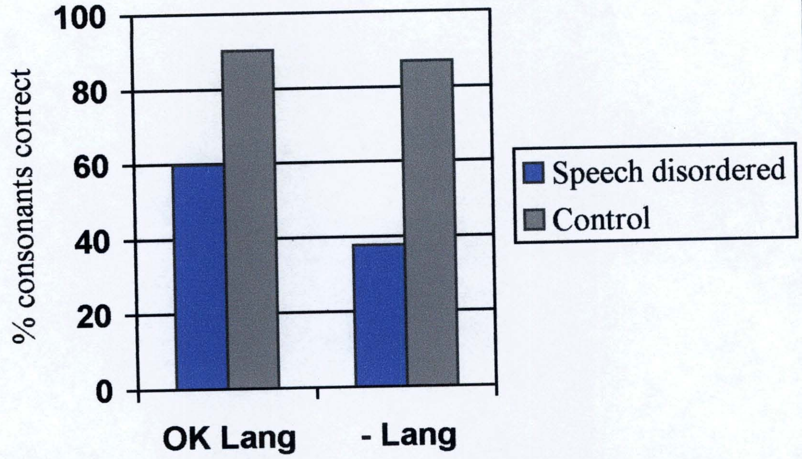


Figure 6.7.
Bar Chart of subgroup differences: Auditory discrimination: picture task at T1

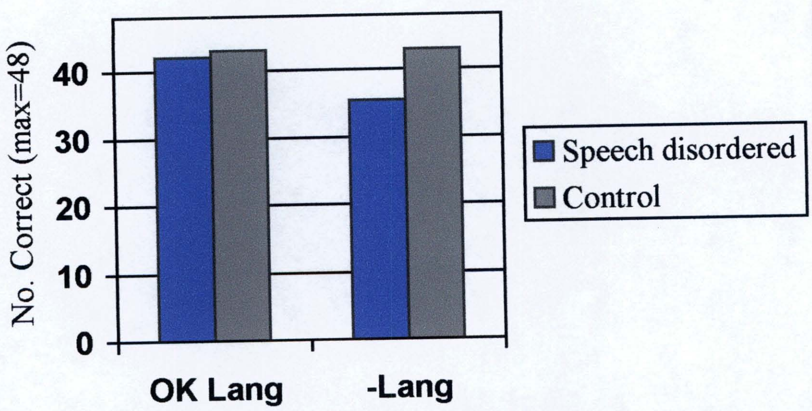


Figure 6.8.
Bar Chart of subgroup differences: Word repetition task at T2

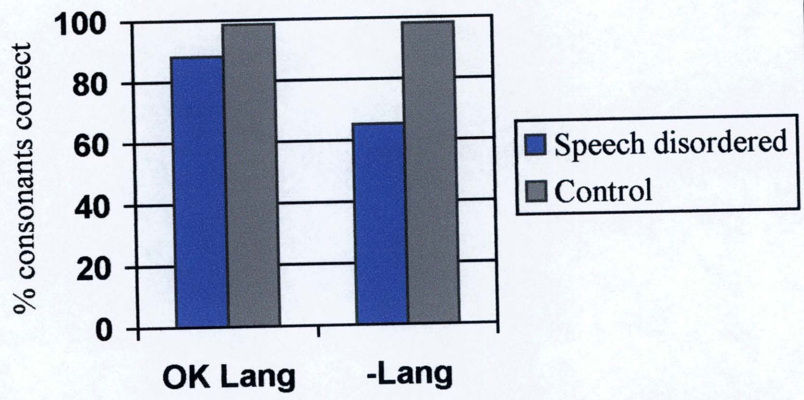


Figure 6.9.
Bar Chart of subgroup differences: Nonword repetition task at T2

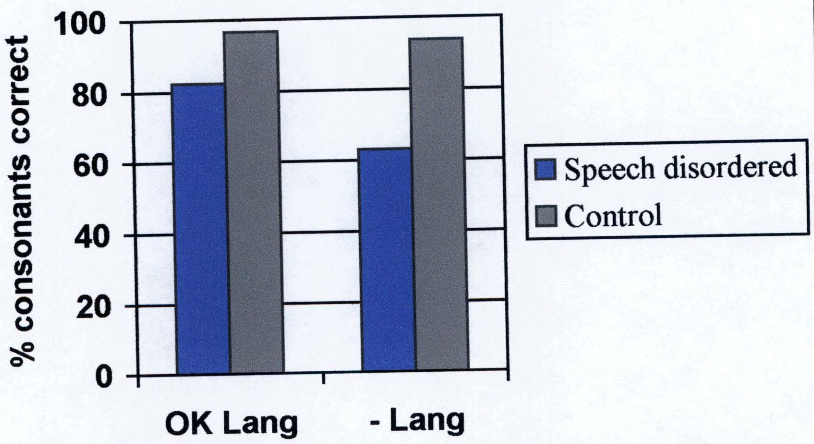


Figure 6.10.
Bar Chart of subgroup differences: LF Word repetition task at T2

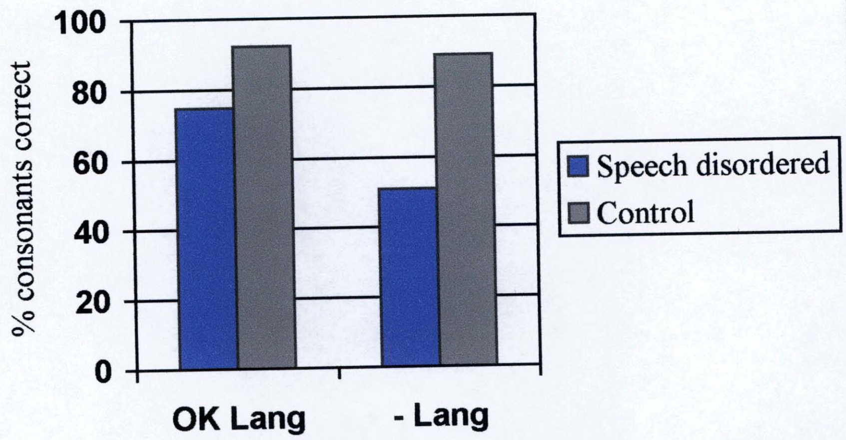


Figure 6.11.
Bar Chart of subgroup differences: LF Nonword repetition task at T2

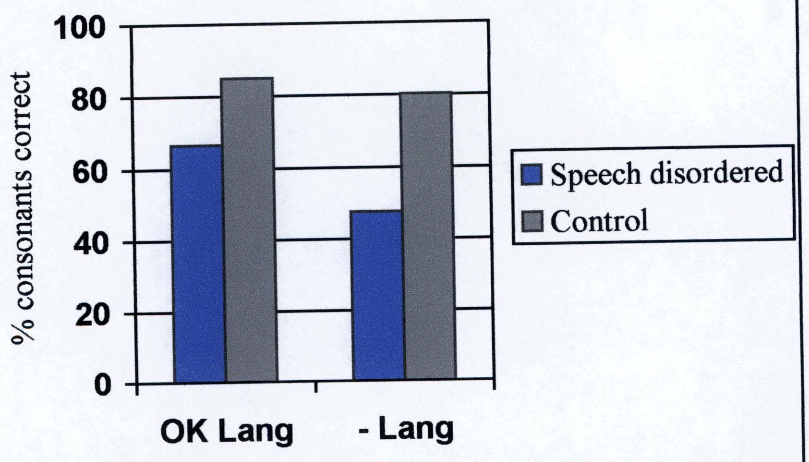


Figure 6.12.
Bar Chart of subgroup differences: Articulatory Naming task at T2

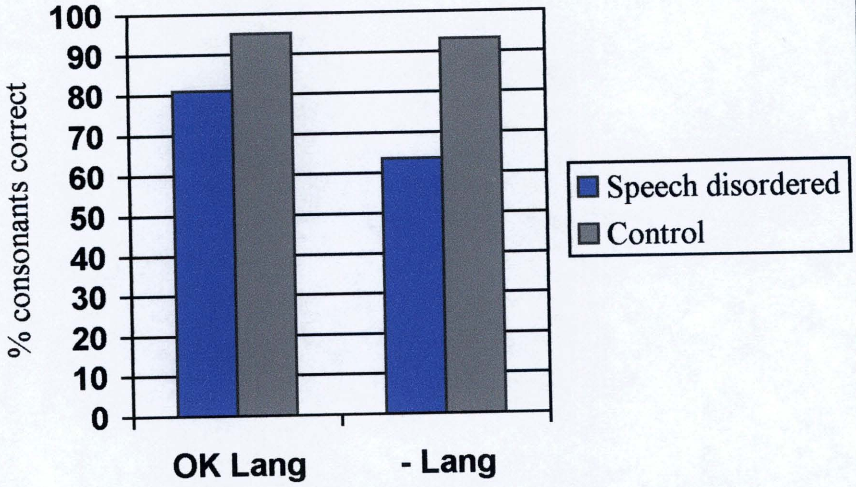


Figure 6.13.
Bar Chart of subgroup differences: Auditory Discrimination ABX task at T3

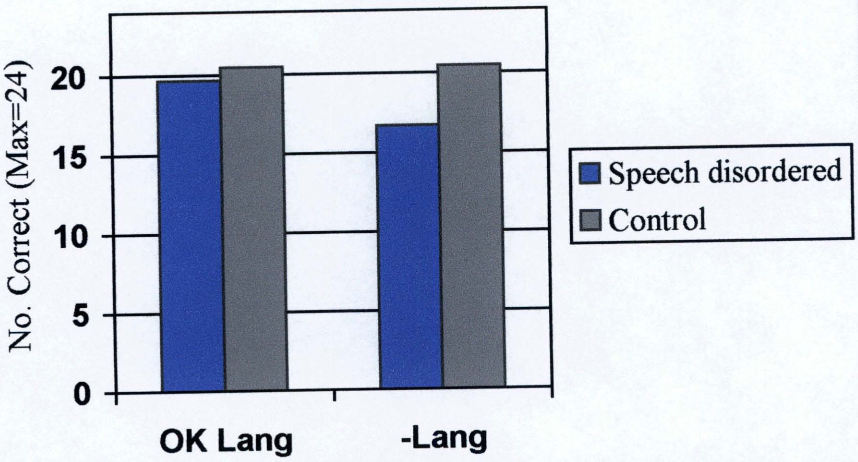


Figure 6.14.
Bar Chart of subgroup differences: LF Nonword repetition task at T3

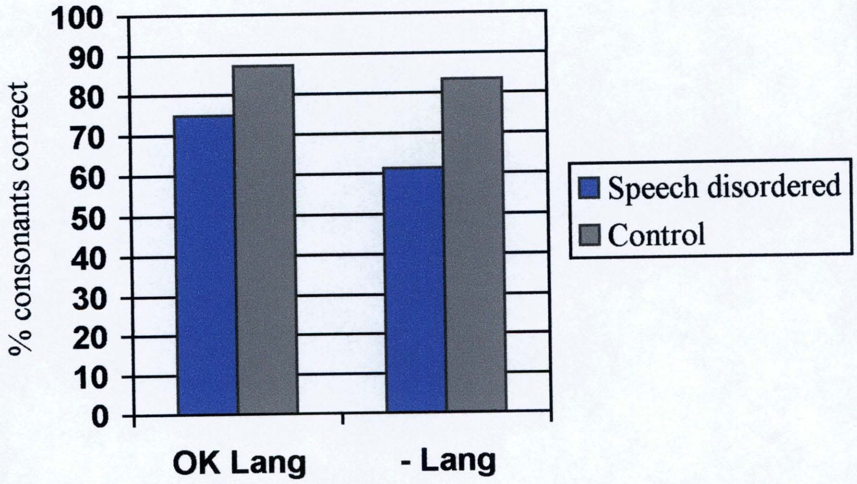
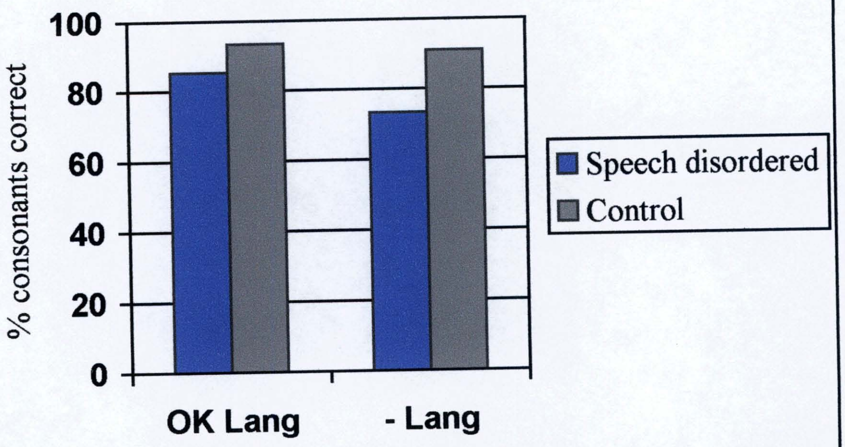


Figure 6.15.
Bar Chart of subgroup differences: LF Word repetition task at T3



6.2.2.2. Language skills

T1: Although children were subgrouped according to language ability, it is possible for children in the so-called 'speech-only' group to have some level of language impairment (given the criterion that a child needed to score below the 10th centile on *two* or more language tests). Differences in language ability between the two subgroups were therefore explored. There was a significant main effect of Group ($F (7,82) = 15.02, p<.001$) and of Subgroup ($F (7,82) = 6.62, p<.001$) as well as a significant interaction ($F (7,82) = 3.74, p<.001$). Univariate analyses showed there to be significant interactions on the Bus story (information score) and RAPT (grammar score).

Tests of simple effects (illustrated in Figures 6.16-6.18) which explored these interactions revealed that the speech and language subgroup performed less well than the speech-only subgroup on both measures (the Bus Story (information score): $F (1,89) = 15.36, p<.001$; and RAPT (grammar score): $F (1,89) = 21.51, p<.001$). However, the speech-only subgroup performed less well than their matched controls on RAPT grammar ($F (1,89) = 10.36, p<.01$), indicating a deficit in this area (but not on the Bus Story information: F (1,89 = .66, ns). The speech/language subgroup scored less well than their controls on both measures: (RAPT grammar: $F (1,89) = 53.89, p<.001$; Bus Story information: F (1,89) =

13.47, $p<.001$). There was also a significant difference between the two control subgroups on RAPT grammar (RAPT grammar: $F(1,89) = 5.67$, $p<.05$) but not Bus Story information: $F(1,89) = 2.92$, ns).

T2: There was a significant main effect of Group ($F(7,82) = 7.61$, $p<.001$) and of Subgroup ($F(7,82) = 4.44$, $p<.001$) as well as a significant interaction ($F(7,82) = 2.41$, $p<.05$). The clinical subgroups performed significantly less well than the controls on all measures except for RAPT (information score). Univariate analyses showed there to be a significant interaction on RAPT (grammar score). Tests of simple effects which explored this interaction revealed that the speech and language subgroup performed less well than the speech-only subgroup ($F(1,89) = 20.53$, $p<.001$). At T2, the speech-only subgroup was no longer significantly different from their matched controls on this test ($F(1,89) = 2.04$, ns). The speech and language subgroup scored less well than their controls ($F(1,89) = 32.24$, $p<.001$). There was no significant difference between the two control subgroups ($F(1,89) = 2.27$, ns).

T3: There was a significant main effect of Group ($F(7,80) = 4.41$, $p<.001$) and of Subgroup ($F(7,80) = 2.51$, $p<.05$) but no significant interaction ($F(7,80) = .18$, ns). The clinical subgroups performed less well than the controls on the language measures (except for RAPT information) but there were no longer any significant subgroup interactions on the individual tests.

Table 6.8.

Mean performance of the Clinical Subgroups and Controls on language measures

	Speech-only	Control 1	Speech/ language	Control 2	Between Ss (Group)		Between Ss (Subgroup)		Group x Subgroup	
T1					F (1,88)	MSE	F (1,88)	MSE	F (1,88)	MSE
Bus Story (information score)	20.39 (6.79)$_a$	21.79 (6.77)$_a$	11.11 (5.14)	19.44 (7.89)	12.10^{c}	45.49	15.7^{c}	45.49	6.32^{a}	45.49
Bus Story (MLU)	7.43 (1.92)	9.59 (2.42)	4.92 (1.50)	8.04 (1.68)	37.82^{c}	3.99	20.86^{c}	3.99	1.56	3.99
RAPT (information score)	29.79 (3.39)	31.22 (2.81)	25.68 (5.40)	29.33 (4.71)	8.89^{b}	15.72	15.77^{c}	15.72	1.34	15.72
RAPT (grammar score)	19.43 (3.78)	23.45 (3.96)	10.05 (4.08)	21.72 (5.02)	80.72^{c}	17.12	39.07^{c}	17.12	19.99^{c}	17.12
Naming	6.96 (2.38)	8.59 (2.83)	5.05 (2.04)	8.22 (3.52)	15.58^{c}	7.45	3.92	7.45	1.13	7.45
BPVS	37.43 (9.68)	43.34 (13.33)	29.58 (9.57)	43.83 (13.04)	17.41^{c}	134.47	3.16	134.47	2.58	134.47
TROG (number of items)	50.14 (10.93)	53.28 (13.75)	37.22 (10.95)	47.41 (16.14)	5.17^{a}	165.33	13.16^{c}	165.33	1.04	165.33
T2					F (1,88)	MSE	F (1,88)	MSE	F (1,88)	MSE
Bus Story (information score)	25.14 (5.92)	29.66 (6.37)	18.67 (8.42)	24.89 (7.44)	12.88^{c}	47.28	14.84^{c}	47.28	.25	47.28
Bus Story (MLU)	9.67 (2.19)	10.65 (2.06)	7.81 (2.58)	10.13 (2.82)	10.59^{b}	5.59	5.72^{a}	5.59	1.55	5.59
RAPT (information score)	33.70 (2.78)	33.88 (2.90)	30.68 (3.14)	32.64 (3.70)	2.38	9.69	10.41^{b}	9.69	1.73	9.69
RAPT (grammar score)	24.93 (4.14)$_a$	26.69 (3.51)$_a$	17.79 (3.22)	25.33 (4.27)	32.68^{c}	14.9	21.01^{c}	14.9	15.32^{c}	14.90
Naming	9.46 (2.57)	11.38 (2.32)	7.68 (2.54)	11.22 (4.19)	21.62^{c}	8.09	4.21^{a}	8.09	1.52	8.09
BPVS	52.11 (11.36)	57.07 (11.32)	42.05 (10.06)	52.88 (17.17)	8.35^{b}	152.33	9.29^{b}	152.33	.71	152.33
TROG (number of items)	61.71 (9.29)	65.0 (8.18)	52.53 (9.49)	60.18 (10.90)	7.16^{b}	86.45	14.27^{c}	86.45	.89	86.45
T3					F (1,86)	MSE	F (1,86)	MSE	F (1,86)	MSE
Bus Story (information score)	28.86 (7.29)	33.20 (5.63)	25.42 (7.52)	28.94 (7.26)	6.42^{a}	46.69	8.73^{b}	46.69	.39	46.69
Bus Story (MLU)	11.44 (2.03)	11.90 (2.29)	9.74 (2.41)	11.61 (2.55)	5.38^{a}	5.30	5.17^{b}	5.3	1.33	5.30
RAPT (information score)	34.75 (2.87)	34.98 (2.73)	33.79 (2.78)	34.72 (3.98)	.91	9.39	1.05	9.39	.19	9.39
RAPT (grammar score)	25.57 (3.23)	27.0 (3.61)	22.26 (5.27)	26.44 (3.75)	11.12^{c}	15.60	5.19^{a}	15.60	2.59	15.60
Naming	11.82 (3.10)	13.54 (2.64)	9.16 (2.65)	12.17 (3.37)	13.05^{c}	8.65	11.72^{c}	8.65	.61	8.65
BPVS	60.21 (10.42)	71.0 (11.19)	52.37 (8.99)	65.33 (15.09)	22.29^{c}	129.98	9.51^{b}	129.98	.01	129.98
TROG (number of items)	69.07 (5.73)	70.73 (6.35)	62.16 (6.19)	68.61 (5.80)	8.97^{b}	36.33	12.59^{c}	36.33	3.16	36.33

Superscript: $^{a}p<.05$; $^{b}p<.01$; $^{c}p<.001$ Note 1: SDs in parentheses Note 2: Significant interactions were explored using simple effects: where these calculations were made and the subgroups did not differ significantly the same subscript is used

Figure 6.16.
Bar Chart of subgroup differences: RAPT (grammar) at T1

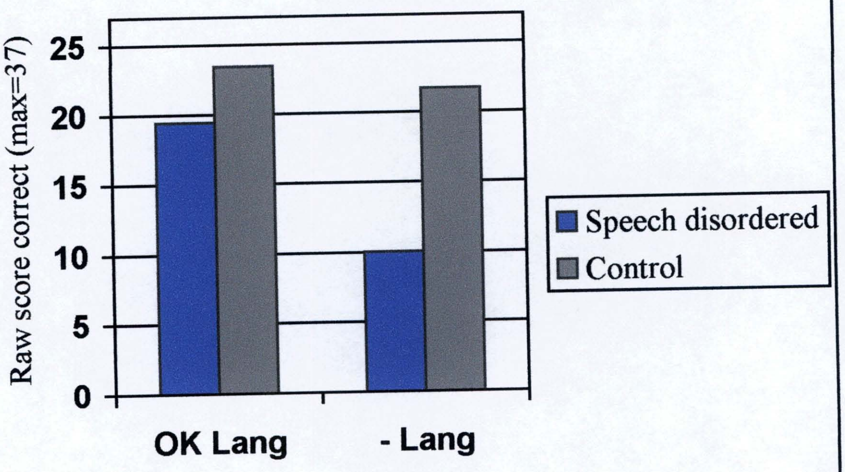


Figure 6.17.
Bar Chart of subgroup differences: Bus Story (information) at T1

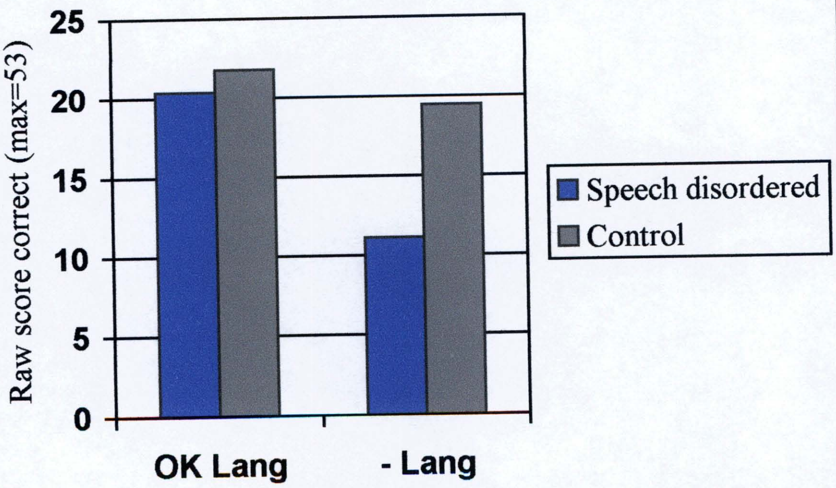
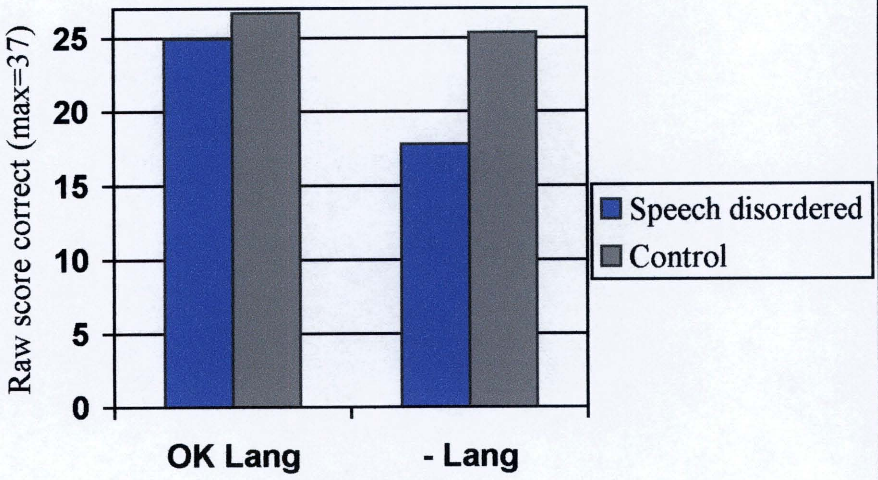


Figure 6.18.
Bar Chart of subgroup differences: RAPT (grammar) at T2



6.2.2.3. Stability of subgroup membership at T3

Using the same criterion as at T1, the cohort was reclassified into speech-only and speech/language subgroups. This found near-identical proportions of children in each subgroup: speech-only: 42.5% (n=20); and speech and language: 57.4% (n=27). However, six children previously in the speech and language subgroup were now classified as speech-only; and seven children previously classified as speech-only were now classified as speech and language impaired.

6.2.2.4. Relationship between speech/language subgroup and speech outcome

In section 6.2.1.1, it was reported that 27.7% of the cohort scored within 1 SD of the control group on a composite measure of speech output. Children classified with speech-only difficulties were found to have better skills throughout the study than those with speech/language difficulties, although their speech skills were not equivalent to that of their controls at T3. The relationship between subgroup membership at T1 and eventual speech outcome was examined to see whether children in the speech-only subgroup were more likely to have resolved speech. Table 6.9 shows the distribution. Children with speech and language difficulties are very likely to have persisting speech problems, with only two children (10.5% of this subgroup) having resolved speech. Children with speech difficulties are also likely to have persisting problems, although a larger proportion than the Speech and language subgroup have resolved speech at T3 (39.3% of this subgroup). A Chi-square found this difference in outcome relative to subgroup membership to be significant (χ^2 (1) = 4.68, p<.05).

Table 6.9.
Percentage of children by speech/language subgroup according to speech outcome at T3

	% Speech-only subgroup (n)	% Speech and language subgroup (n)
Resolved speech at T3	39.3 (11)	10.5 (2)
Persisting speech problems at T3	60.7 (17)	89.5 (17)

Note: n = number of children

6.3. Discussion

6.3.1. Heterogeneity

As expected, considerable heterogeneity existed within the speech disordered group on speech output, speech input and language measures. Notably, more variation was noted in speech output skills compared to speech input skills and language ability. Children with speech difficulties showed dramatic deficits compared to the control group on the speech output composite at T1. At T2 and T3, changes in the level of deficit had occurred, with fewer children showing these large discrepancies compared to the control group and some children performing like controls on these measures. On the speech input composite and language composite, the differences with the control group were less marked.

Whilst group differences had been noted in Chapter 4 on most of these measures, the analysis reported in this chapter reveals a proportion of the speech disordered group performing within normal limits on speech output (at T2 and T3) and on speech input and language skills (throughout). Thus, for some children, speech output difficulties were a transient problem that had resolved within one or two years of entering the study. By T3, 27.7% of the group performed within 1 SD of the control group's mean on a composite measure of speech output. Also, dissociations between measures are possible within this population, with some children showing isolated speech difficulties, and no co-occurring speech input difficulties and/or language difficulties.

However, differing results obtained in analyses of co-occurring deficits on the speech input and language measures suggest it may be difficult to be precise about the exact proportion of children with co-occurring problems. Results using composite scores of language and composite scores of the speech input tasks revealed a lower proportion of children exhibiting these difficulties than when tasks were examined individually. For example, at T1, whilst 25% of the speech disordered group exhibited speech input difficulties using a composite measure, 55% showed difficulties when calculating how many children scored below normal limits on any one of the three tasks, rather than the composite. The composite score masked overall difficulties because performance on one of the tasks, the AD: ABX task, was mainly age-appropriate, where controls were scoring at similar chance levels. In addition, the –1 SD cut-off point, chosen to reflect 'clinical significance' may have resulted in less stability of categorisation than a greater cut-off point. Estimating prevalence of certain speech and language skills is thus heavily influenced by task design and criteria for defining impairment.

6.3.2. Speech/language analysis

The issue of defining co-occurring difficulties is further exacerbated by attempts to classify into subgroups using these measures. There is no accepted procedure for how to subclassify. Children were classified into two subgroups according to language skills based on a criterion of scoring below the 10th centile on two or more language measures. This criterion was chosen to be in line with other studies (for example, a 10th centile cut-off point was also used by Bird et al., 1995), but there is no consensus across studies, which classify in different ways. It is also difficult to make direct comparisons with other studies as different measures are used, which may not be directly comparable in the skills they tap and which may vary in task sensitivity. Further, there was some instability of subgroup membership over time, with several children changing clinical profile at T3 (in both directions). A reclassification at T3 revealed that the proportion of children in each subgroup remained similar, but the membership had changed. These changes may be the result of genuine changes/ fluctuations in performance or may be due to measurement error. Despite this, the subgroup classification at T1 according to presence or absence of additional language difficulty did reveal significantly different profiles of performance.

Moreover, the proportion of children with additional language difficulties (40%) compared well with the sample studied by Bird, Bishop & Freeman (1995) who found 38.7% of their sample of 31 children had both speech and language difficulties and also those recruited by Lewis et al. (2000) which found 46.2% of their sample of 52 had additional language difficulties. However, both these studies differ from Shriberg et al. (1999) who found 11-15% of children with persisting speech delay also had SLI. This study estimated co-morbidity from a demographically representative sample of 1328 6-year-old children. Differing proportions are therefore partly due to the older age of their sample, but differences are mainly attributable to the fact that Shriberg et al.'s study specifically addressed co-morbidity of language difficulties with speech delay in the general population. The increased incidence reported in this chapter does not reflect actual co-morbidity in the general population as sampling was from a speech and language therapy population. However, co-morbidity estimates from studies of clinical samples are still considered to be of some value (Angold, Costello & Erkanli, 1999). If this result is generalised to other clinical samples, i.e. what one is likely to encounter within the population of children within a speech and language therapy service, then this data may be of more value than estimates from a general population study. Further, this kind of matched-control methodology is useful when identifying the implications of such co-occurring problems (Angold et al., 1999). Indeed, co-occurring language problems were differentiated from speech-only difficulties in this study in other aspects of performance and relative to controls, as described in the following section.

6.3.3. Profiles of performance of the Speech/language subgroup

Children with additional language difficulties also have more severe speech output difficulties and co-occurring speech input difficulties. Speech input difficulties differentiated the two subgroups at T1 and T3. At T1, AD: picture task differentiated the subgroups and at T3, the AD: ABX task was a differentiator. The speech-only subgroup was not significantly different from their controls on these measures, showing intact input skills. Input processing problems are therefore associated with additional language difficulties.

In broad agreement with the results of Lewis et al. (2000), children with a more pervasive profile of speech/language difficulties also had more severe deficits in speech output to speech-only children on measures of word and nonword repetition at each testing phase and on articulatory naming at T1 and T2. The speech-only subgroup continued to be significantly different from their controls on these speech output measures at T2 and T3, showing that, as a subgroup, they have persisting speech difficulties, but these are of a milder nature than for the speech and language subgroup. The majority of both subgroups have persisting speech difficulties. However, a significantly greater proportion of children in the speech and language subgroup has persisting speech problems (89.5%) compared to the speech-only subgroup (60.7%). Whilst a pervasive profile therefore indicates a persisting speech problem, a specific deficit shares a less clear-cut relationship with eventual outcome, with some children showing a good outcome and others continuing to have speech problems. This prospective analysis therefore does not successfully differentiate speech outcome, though it does show that pervasive problems are more likely to result in a persisting speech problem. Overall, the speech/language classification seems to have captured two distinct profiles of disorder: a group of children with specific speech difficulties and a group of children with more severe speech output problems as well as speech input and language difficulties. As these results replicate those of Lewis et al., who followed up their cohort at the age of 8/9, it can be hypothesised that this pattern of performance might continue beyond T3, later in development.

The previous findings are confirmed on the co-occurrence of language difficulties in children with speech problems and of more severe speech difficulties in children with additional language difficulties. The findings on speech input are also consistent with other work showing that types of auditory discrimination difficulties are common in some children with speech difficulties (Broen et al., 1983; Bird & Bishop, 1992). Indeed the subgroup analysis combines these two sets of findings by uncovering a relationship between speech output, speech input and language tasks: language skill seems to be associated not just with speech production skills, but with speech processing skills (i.e. input and output processing).

However, it could be argued that what the classification really captures is a group of children with more severe speech output difficulties. It is possible that children with an initial and more severe speech difficulty are classified as 'language impaired' because of the difficulty analysing and scoring expressive language tasks when the child's speech is largely unintelligible. Further analysis would uncover whether it is the additional language impairment that is the contributing factor here, or whether a more severe speech difficulty depresses language scores. If the latter were the case, it would then imply that children fall on a continuum of speech difficulty rather than being clinically distinct in terms of their language skills. Alternatively, the classification might capture a more pervasive difficulty, due to the interaction of these different skills in development or may be due to an unknown, underlying factor.

Nonetheless, the finding on speech input strengthens the argument that the language classification at T1 does capture two clinically different subgroups. Children with speech difficulties alone, as well as having age-appropriate language skills at T1 and less severe speech skills, also have age-appropriate speech input skills. It is therefore possible to have a very specific speech difficulty that is confined to speech output processing. This finding clearly differentiates the subgroups: not only are the speech and language subgroup performing less well than the speech-only subgroup, but the speech-only subgroup are not significantly different from the control group. Again, this result does not address questions of causality. One might expect that reduced ability to process speech input might have a causal influence on both a child's level of speech difficulty and their language ability. The inter-relatedness of the skills and the type of analysis conducted here make this a speculative assumption.

The presence of additional language difficulties does identify children who will also have more pervasive problems affecting the severity of the speech output difficulty as well as speech input. However, it must be emphasised that despite the division of the group by language ability at T1, only two language tests (the Bus Story, information score and RAPT, grammar score) actually differentiated significantly the two subgroups. By T3, these differences were no longer significant. The measures with which the children were defined and subclassified, were less consistent at differentiating the two subgroups than the speech processing measures. These results suggest that changes over time on language tests were occurring across the subgroups, reflecting a lack of stability of classification. A similar finding of lack of stability of classification over time has been found in subgrouping children identified with speech/language difficulties (Bishop & Edmundson, 1987a; Conti-Ramsden & Botting, 1999) though the current classification had the advantage of being simple (i.e. it was two-way) and so likely to be more reliable than more complex schemes.

As well as describing a more pervasive difficulty in children with co-occurring speech and language problems, the analysis highlights the changing nature of these children's problems. As discussed in Chapter 4, methodological issues of measurement make it difficult to re-measure the same skills at different ages. Rather than concluding that results are clouded by methodological problems, it is suggested that the lack of stability within the subgroups reveals a characteristic of the disorder that requires further investigation, i.e. detailed analysis of the interactive relationships between different elements of the speech and language processing system. These relationships will be explored in Chapter 9. Before reporting this analysis, a second subgroup analysis is reported in Chapter 7, which overcomes the problems of a prospective analysis by a retrospective classification based on the children's speech outcome at T3.

Chapter 7
Identification of speech outcome through retrospective subgroup analysis

7.1. Introduction

The previous chapter reported analyses of the speech disordered group according to whether the children had additional language difficulties at T1. A subgroup analysis revealed some significant differences between subgroups and led to tentative conclusions on the existence of subgroups in this population. However, it was unclear whether the defining characteristic that differentiated the two subgroups was actually their language skills. It could also have been the level of severity of the speech difficulty or the occurrence of speech input difficulties (found to be associated with the subgrouping classification) that was the core differentiating factor. The subgrouping also failed to show a clear-cut relationship with outcome. In addition, what tests/skills differentiated the two subgroups was inconsistent over the testing phases and subgroup membership itself was unstable over time. This way of subgrouping, though highlighting some trends in performance, lacked precision.

Another way of subgrouping this population is retrospectively in terms of their later speech skills, i.e. what skills differentiated those children whose speech difficulties later resolve from those children whose difficulties persist. This approach does not presuppose a particular theoretical stance, for example, that type of speech error or additional language difficulty is the key feature that differentiates this population. Instead, this approach adopts a more pragmatic or clinically motivated approach which recognises that some early speech difficulties resolve in middle childhood (5/6 years). What is central to this analysis is the child's future speech status: it looks for tasks and factors that will differentiate those children whose speech difficulties will resolve compared to those children whose difficulties are likely to persist.

Shriberg, Kwiatowski & Gruber (1994) subgrouped in this way in their one-year follow-up of children with speech disorders but they found no useful clinical markers that differentiated the children a year earlier. In their study, none of the following factors differentiated performance: a speech profile of English consonants, demographic data on gender, age, birth order, number of children in family, father's and mother's education, data on hearing, developmental history, oromotor skills, cognitive-linguistic levels and amount of intervention. Eight of 87 risk factor contrasts showed a significant difference between the groups and in six of these the normalised group showed more involvement. The two measures that did show the non-normalised group to be performing less well, palatine tonsils and pharyngeal structure, are not of immediate clinical interest.

In this chapter, the performance of the group was examined retrospectively according to whether the child's speech difficulties had resolved by T3 or were persisting. As previously reported, 27.7% of the group had age-appropriate speech at T3. The clinical profile of these children compared to those who were experiencing persisting speech problems could help to identify why the outcome of these subgroups is so different and thus highlight useful clinical markers with which to differentiate later outcome. As well as examining speech processing and language differences, this analysis also looks at a broader range of potential contributing factors, i.e. developmental history, family history and amount and type of intervention. Whether differences between the subgroups reflect differences in severity of difficulty or whether the persisting subgroup is exhibiting more pervasive problems is examined. Also, potential differences in rate of development between the two subgroups including word/nonword repetition will be examined as it is possible that resolving speech problems are mediated by a faster rate of speech development or persisting speech problems with an arrested or slowed rate of speech development.

Finally, a cluster analysis is conducted to evaluate a statistically defined subgrouping compared to the outcome classification previously discussed. It is possible to compare the ways in which classification is made (i.e. severity or pervasiveness criterion) whether either classification system relates to the clinical questionnaire data which reported numbers of children who have been discharged and so can clarify the relationship between profile of performance and outcome classification.

7.1.1. Research questions

1. What developmental markers at ages 4, 5 and 6 differentiate those children whose speech difficulties persist compared to those whose difficulties have resolved by age 6?
2. Is speech outcome related to how pervasive the speech and language difficulty is and/ or the severity of the speech difficulty?
3. What is the relationship between speech outcome and rate of speech development?
4. Does the pattern of word/nonword performance vary across speech outcome subgroup?
5. Does a cluster analysis reveal similar patterns/profiles of performance as the outcome classification of resolved/persisting?

7.2. Results

7.2.1. Speech, language and nonverbal markers of children with resolved or persisting speech skills

In order to examine what speech processing and language skills differentiate children whose speech has resolved and children whose speech difficulties persist, children in the speech disordered group were subdivided at T3 according to their speech output abilities. If a child scored below –1 SD on a composite z-score of Articulatory naming, LF word repetition and LF nonword repetition, he/she was classified as having 'persisting' speech difficulties. If a child scored above –1 SD, he/she was classified as 'resolved'. 27.7% (n = 13) of children were classified as resolved and 72.3% (n = 34) as having persisting speech difficulties. A cut-off of –1 SD was chosen as this is an agreed level for clinical significance, though not of strictly statistical significance. One child in the resolved subgroup was subsequently found to have nonword repetition difficulties, whilst being age-appropriate on the composite. However, the stringent classification was successful at categorising children who had more subtle speech output problems, as revealed by nonword repetition. (Five children with nonword repetition problems would have been classified as 'resolved' if articulatory naming alone had been used to classify; six children with nonword repetition problems would have been classified as 'resolved' if word repetition alone had been used for classification.)

To explore whether there were developmental markers at any of the testing phases, a series of multivariate analyses were conducted with Speech Outcome as a between-subjects factor with three levels (Resolved, Persisting and Controls). Means and SDs by subgroup, univariate analyses and exploration of main effects (using a Bonferroni correction) are reported for the three testing phases in Table 7.1 (speech processing), Table 7.2 (language measures) and Table 7.3 (nonverbal measures), and summarised in Table 7.4.

7.2.1.*1*. Speech processing skills

T1: A Multivariate analysis was conducted with one between-subjects factor (Outcome group) and six dependent measures (Word repetition, Nonword repetition, Articulatory naming, AD: same/different, AD: picture task and AD: ABX). There was a significant main effect of Outcome group ($F\ (12,164) = 23.08$, $p<.001$). Univariate analyses and subsequent exploration of main effects show that, at T1, the children whose speech had resolved by T3 were already performing significantly better than the children whose problems persist on speech output tasks, although they were scoring less well than controls. Children with persisting problems also had more difficulty than both children with resolved difficulties and controls on the AD: ABX task; and more difficulty than controls on the AD: picture task. The resolved subgroup was scoring equivalently to controls on all the speech input tasks.

T2: A Multivariate analysis was conducted with one between-subjects factor (Outcome group) and eight dependent measures (Word repetition, Nonword repetition, Articulatory naming, LF word repetition, LF nonword repetition, AD: same/different, AD: picture task and AD: ABX). There was a significant main effect of Outcome group ($F\ (16,166) = 7.12$, $p<.001$). Univariate analyses show significant differences of Outcome group on all measures. Post hoc analyses showed that there were significant differences on both speech output and speech input tasks between the Resolved and Persisting speech subgroups, excluding the AD: picture task. A similar degree of difference in speech performance between the Resolved and the Persisting speech subgroups existed at T2 as at T1. In addition, at T2, children in the Resolved subgroup now performed like controls on all speech output tasks with no significant differences between them. There were also no significant differences between the Resolved subgroup and controls on the speech input tasks.

T3: A Multivariate analysis was conducted with one between-subjects factor (Outcome group) and five dependent measures (LF word repetition, LF nonword repetition, Articulatory naming, AD: picture task and AD: ABX). There was a significant main effect of Outcome group ($F\ (10,164) = 9.62, p<.001$). At T3, as expected from the classification, the Resolved and Persisting subgroups differed significantly on speech output tasks and the Resolved subgroup performed like controls. It was noted that the mean difference between the resolved and persisting subgroups on the speech output tasks had narrowed since T2, with the exception of LF nonword repetition where the mean difference between subgroups remained similar at T3. In addition, the Resolved and Persisting subgroups differed on AD: ABX, while the Resolved speech subgroup was no different from controls.

In summary, children classified as 'resolved' at T3 are, by T2, already performing better than children with persisting speech difficulties on speech output at T1 and like control children on all speech output tasks. Children with persisting speech problems perform less well than children with resolved speech difficulties on speech input tasks at T1, T2 and T3.

7.2.1.2. Language skills

T1: A Multivariate analysis was conducted with one between-subjects factor (Outcome group) and seven dependent measures (Bus Story (information score), Bus Story (MLU), RAPT (information score), RAPT (grammar score), Naming, BPVS and TROG). There was a significant main effect of Outcome group ($F\ (14,166) = 5.82$ $p<.001$). Univariate analyses showed significant group differences on all Language measures. Tests of simple effects showed that the Resolved subgroup was performing significantly better than the Persisting subgroup on the Bus Story (information and MLU score). Means also show that there are differences between the two clinical subgroups on the other language scores, but due to large variance (as noted by high SDs), these differences are non-significant. The Resolved subgroup was not significantly different from the controls on any of these language measures and the Persisting subgroup was significantly different to controls on all measures, except RAPT (information score). Note: the finding on RAPT (information score), with no significant differences between the subgroups on the post hoc analysis contradicts the overall significant F value of the univariate analysis. This may be due to the use of a Bonferroni correction on the post hoc analysis. Means show a similar trend in performance to the other language tasks, with the Persisting speech subgroup scoring less well than the other two subgroups.

T2: A Multivariate analysis was conducted with one between-subjects factor (Outcome group) and seven dependent measures (Bus Story (information score), Bus Story (MLU), RAPT (information score), RAPT (grammar score), Naming, BPVS and TROG). There was a significant main effect of Outcome group ($F(14,166) = 3.73$, $p<.001$). Univariate analyses showed significant group differences on all of the Language measures. Tests of simple effects showed that the Resolved subgroup scored significantly better than the Persisting subgroup on RAPT (information and grammar score). As before at T1, mean differences between the two clinical subgroups were noted on other language tests, but these differences were non-significant. The Resolved subgroup was not significantly different from the controls on language measures (they scored slightly higher on RAPT information score). The Persisting subgroup was significantly different from controls on all language measures, except the RAPT (information score).

T3: A Multivariate analysis was conducted with one between-subjects factor (Outcome group) and seven dependent measures (Bus Story (information score), Bus Story (MLU), RAPT (information score), RAPT (grammar score), Naming, BPVS and TROG). There was a significant main effect of Outcome group ($F(14,162) = 3.19$, $p<.001$). Univariate analyses showed significant group differences on all measures. Further analysis showed that the Resolved subgroup scored significantly better than the Persisting subgroup on RAPT (grammar and information score), Bus Story (MLU), BPVS and TROG. The Resolved subgroup was not significantly different from the controls on any of these measures. The Persisting subgroup was significantly different from the controls on all measures, except RAPT (information score).

In summary, children with persisting speech problems perform less well than children with resolved speech difficulties on some language measures at T1, T2 and T3. At T1 and T2, significant subgroup differences were found on measures of expressive language. Differences on receptive language tests did not reach significance. At T3, performance was significantly differentiated on expressive and receptive language measures.

7.2.1.3. Nonverbal skills

Differences in nonverbal ability by subgroup (either at a younger age (T1) or concurrently to the speech classification at T3) were examined. A Multivariate analysis was conducted with one between-subjects factor (Outcome group) and four dependent measures (Block Design T1, Picture Completion T1, Block Design T3 and Picture Completion T3 (standard scores)). There was no significant main effect of outcome group ($F(8,170) = 1.55$, ns). However, univariate analyses showed a significant group difference on Picture Completion at T3: simple effects showed this difference to be between the Persisting speech subgroup and the controls. To explore this further, a t-test was carried out comparing the persisting speech subgroup with their matched controls. This showed that, on this nonverbal measure, the persisting speech subgroup was no longer matched to their original controls ($t = (64)\ -2.06$, $p<.05$).

Table 7.1.

Mean performance of the Speech outcome subgroups and Controls on measures of speech processing

	Resolved speech subgroup (n=13)	Persisting speech subgroup (n=34)	Controls (n=47)	Between Ss (Group)	
T1				F (2,88)	MSE
Word repetition pcc	63.84 (7.27)	43.74 (16.51)	92.82 (5.48)	183.76[c]	118.61
Nonword repetition pcc	62.34 (6.62)	42.90 (14.87)	90.39 (5.67)	199.73[c]	103.43
Articulatory naming pcc	64.25 (12.0)	45.83 (17.37)	88.90 (9.81)	92.89[c]	178.49
AD: picture (Max=48)	41.38 $(5.14)_{ab}$	38.21 $(6.45)_{a}$	42.94 $(4.34)_{b}$	4.55[a]	.87
AD: ABX (Max=12)	8.31 $(1.38)_{a}$	6.38 (2.21)	7.87 $(2.01)_{a}$	4.73[b]	1.3
AD: S/D (Max=20)	14.6 $(4.1)_{ab}$	13.8 $(3.9)_{a}$	16.63 $(3.03)_{b}$	2.89[a]	2.42
T2				F (2,90)	MSE
Word repetition pcc	93.81 $(6.54)_{a}$	73.38 (20.57)	98.40 $(2.32)_{a}$	38.91[c]	163.44
Nonword repetition pcc	90.11 $(9.43)_{a}$	68.68 (19.39)	95.41 $(5.10)_{a}$	44.06[c]	163.08
Articulatory naming pcc	87.58 $(8.03)_{a}$	68.70 (17.22)	94.28 $(3.91)_{a}$	51.93[c]	125.07
LF word repetition pcc	83.70 $(8.50)_{a}$	58.05 (20.09)	90.86 $(6.38)_{a}$	60.47[c]	178.46
LF nonword repetition pcc	74.58 $(8.21)_{a}$	52.96 (17.04)	83.17 $(8.66)_{a}$	59.97[c]	152.55
AD: picture (Max=48)	45.92 $(2.14)_{ab}$	43.56 $(3.88)_{a}$	45.59 $(3.83)_{b}$	6.41[a]	.68
AD: ABX (Max=24)	19.23 $(2.24)_{a}$	14.88 (3.51)	18.11 $(3.32)_{a}$	9.42[c]	1.03
AD: S/D (Max=20)	18.92 $(1.44)_{a}$	16.59 (2.93)	18.27 $(2.15)_{a}$	5.94[b]	.82
T3				F (2,88)	MSE
Articulatory naming pcc	91.13 $(4.70)_{a}$	80.55 (11.30)	93.94 $(4.88)_{a}$	26.14[c]	62.06
LF word repetition pcc	92.23 $(3.66)_{a}$	76.03 (12.76)	92.51 $(5.77)_{a}$	34.41[c]	76.73
LF nonword repetition pcc	84.78 $(5.57)_{a}$	63.41 (12.48)	85.66 $(8.69)_{a}$	50.07[c]	101.62
AD: picture 2 (Max=20)	19.31 $(.95)_{a}$	18.82 $(1.0)_{a}$	18.05 $(2.22)_{a}$	.78	.16
AD: ABX (Max=24)	20.85 $(1.57)_{a}$	17.48 (2.94)	20.45 $(2.46)_{a}$	13.55[c]	.48

Superscript: [a] $p<.05$; [b] $p<.01$; [c] $p<.001$

Note 1: SDs in parentheses

Note 2: Significant group differences were explored, with a Bonferroni adjustment for multiple comparisons.

Where these calculations were made and the subgroups did not differ significantly the same subscript is used. Thus, where no subscript appears for resolved, persisting or control group means, then each differs significantly from the remaining two subgroups ($p<.05$).

Note 3: Raw scores are reported here for speech input tasks, although *d'* was used in all calculations.

Table 7.2.

Mean performance of the Speech outcome subgroups and Controls on language tasks

	Resolved speech subgroup (n=13)	Persisting speech subgroup (n=34)	Controls (n=47)	Between Ss (Group)	
T1				F (2,89)	MSE
Bus Story (information score)	22.23 (9.92)$_{a}$	14.50 (5.38)	20.89 (7.23)$_{a}$	9.89^{c}	50.26
Bus Story (MLU)	7.80 (3.11)$_{a}$	5.89 (1.35)	9.0 (2.28)$_{a}$	20.59^{c}	4.59
RAPT (information score)	29.12 (5.41)$_{a}$	27.75 (4.46)$_{a}$	30.50 (3.73)$_{a}$	4.29^{a}	18.38
RAPT (grammar score)	19.23 (4.71)$_{ab}$	14.26 (5.98)$_{a}$	22.79 (4.42)$_{b}$	25.3^{c}	23.1
Naming	6.92 (3.09)$_{ab}$	5.91 (2.09)$_{a}$	8.45 (3.08)$_{b}$	7.85^{c}	7.71
BPVS	37.46 (11.60)$_{ab}$	33.03 (9.66)$_{a}$	43.53 (13.08)$_{b}$	8.34^{c}	139.55
TROG (number of items)	51.08 (12.15)$_{ab}$	42.73 (12.09)$_{a}$	51.11 (14.78)$_{b}$	4.06^{a}	182.90
T2				F (2,89)	MSE
Bus Story (information score)	26.69 (7.97)$_{ab}$	21.0 (6.95)$_{a}$	27.83 (7.12)$_{b}$	9.44^{c}	51.42
Bus Story (MLU)	10.06 (2.36)$_{ab}$	8.50 (2.44)$_{a}$	10.45 (2.37)$_{b}$	6.80^{b}	5.74
RAPT (information score)	34.38 (3.87)$_{a}$	31.75 (2.72)$_{b}$	33.40 (3.25)$_{ab}$	4.07^{a}	10.21
RAPT (grammar score)	25.85 (5.11)$_{a}$	20.59 (4.45)	26.17 (3.83)$_{a}$	17.36^{c}	18.19
Naming	9.69 (2.98)$_{ab}$	8.38 (2.51)$_{a}$	11.32 (3.13)$_{b}$	11.34^{c}	8.32
BPVS	52.31 (14.04)$_{ab}$	46.41 (10.68)$_{a}$	55.52 (13.74)$_{b}$	4.92^{b}	164.25
TROG (number of items)	63.54 (10.71)$_{ab}$	55.88 (9.51)$_{a}$	63.22 (9.46)$_{b}$	6.28^{b}	94.13
T3				F (2,87)	MSE
Bus Story (information score)	30.08 (6.44)$_{ab}$	26.47 (7.72)$_{a}$	31.42 (6.63)$_{b}$	4.77^{a}	49.56
Bus Story (MLU)	12.12 (2.19)$_{a}$	10.22 (2.19)	11.78 (2.38)$_{a}$	5.56^{b}	5.26
RAPT (information score)	36.15 (2.90)$_{a}$	33.68 (2.54)$_{b}$	34.88 (3.26)$_{ab}$	3.73^{a}	8.76
RAPT (grammar score)	27.0 (2.77)$_{a}$	23.18 (4.52)	26.77 (3.63)$_{a}$	5.92^{b}	14.80
Naming	12.54 (3.23)$_{ab}$	10.08 (2.93)$_{a}$	12.98 (3.0)$_{b}$	9.16^{c}	9.14
BPVS	62.23 (15.95)$_{a}$	55.06 (6.84)	68.68 (13.07)$_{a}$	7.31^{c}	100.74
TROG (number of items)	70.08 (5.11)$_{a}$	64.82 (6.84)	69.86 (6.16)$_{a}$	6.67^{b}	39.77

Superscript: $^{a}p<.05$; $^{b}p<.01$; $^{c}p<.001$

Note 1: Raw scores are reported

Note 2: SDs in parentheses

Note 3: Significant group differences were explored, with a Bonferroni adjustment for multiple comparisons.
Where these calculations were made and the subgroups did not differ significantly the same subscript is used. Thus, where no subscript appears for resolved, persisting or control group means, then each differs significantly from the remaining two subgroups (p<.05).

Table 7.3.

Mean performance of the Speech outcome subgroups and Controls on nonverbal tasks

	Resolved speech subgroup (n=13)	Persisting speech subgroup (n=34)	Controls (n=47)	Between Ss (Group)	
				F (2,88)	MSE
Block Design T1 (ss)	10.92 (1.93)	10.03 (2.39)	10.68 (2.73)	.98	6.41
Picture Completion T1 (ss)	12.77 (2.20)	11.85 (2.05)	12.21 (2.22)	.95	4.59
Block Design T3 (ss)	9.38 (3.66)	8.44 (3.16)	9.84 (2.98)	1.91	9.92
Picture Completion T3 (ss)	9.54 (3.10)$_{ab}$	8.56 (2.09)$_{a}$	10.25 (2.64)$_{b}$	4.31^{a}	6.36

Superscript: $^{a}p<.05$; $^{b}p<.01$; $^{c}p<.001$

Note 1: SDs in parentheses

Note 2: ss = standard score

Note 3: Significant group differences were explored, with a Bonferroni adjustment for multiple comparisons. Where these calculations were made and the subgroups did not differ significantly the same subscript is used. Thus, where no subscript appears for resolved, persisting or control group means, then each differs significantly from the remaining two subgroups (p<.05).

Table 7.4.
Summary table showing the pattern of performance on the test battery according to Speech outcome subgroup differences

	Time 1	Time 2	Time 3
Nonverbal	Block Design		Block Design
	Picture Completion		PICTURE COMPLETION
Speech Output	WORD REPETITION	WORD REPETITION	
	NONWORD REPETITION	NONWORD REPETITION	
	ARTICULATORY NAMING	ARTICULATORY NAMING	ARTICULATORY NAMING
		LF WORD REPETITION	LF WORD REPETITION
		LF NONWORD REPETITION	LF NONWORD REPETITION
Speech Input	Auditory discrimination: picture	Auditory discrimination: picture	Auditory discrimination: picture 2
	AUDITORY DISCRIMINATION: ABX	AUDITORY DISCRIMINATION: ABX	AUDITORY DISCRIMINATION: ABX
	Auditory discrimination: same/different	AUDITORY DISCRIMINATION: SAME/DIFFERENT	
Expressive Language	Naming	Naming	Naming
	BUS STORY	Bus Story	BUS STORY (MLU)
	RAPT (Info)	R (NFO	RAP (IN O)
Receptive Language	BPVS	BPVS	BPVS
	TROG	TROG	TROG

RED BOLD = the resolved speech subgroup have significantly higher scores than the persisting speech subgroup

Filled yellow box = no significant difference between the resolved speech subgroup and the Control group

Filled turquoise box = neither speech outcome subgroups significantly different to the Control group

7.2.2. Classification of Speech Outcome groups

Discriminant function analyses were conducted in order to examine which tasks most successfully predicted children's speech classification at T3. Tasks that significantly differentiated the subgroups at T1 and T2 were therefore entered into a discriminant function analysis.

T1: A discriminant function analysis was performed using word repetition, nonword repetition, Articulatory naming, AD: ABX and the Bus Story (information and MLU score), to predict group membership (resolved and persisting speech) of the speech disordered group. The independent variables were entered together and a significant Chi-square was uncovered, with 75.8% of cases (34/45) correctly classified (χ^2 (6) = 20.52, p<.005). Measures were entered separately to identify which tasks might classify what best. The auditory task was the least successful at classifying cases with 66.7% correctly classified (χ^2 (1) = 7.68, p<.01). The speech tasks classified a larger proportion correctly, 72.3%, (χ^2 (3) = 16.33, p<.001). When the language tasks (the Bus Story scores) were entered, 80.9% of cases were correctly classified (χ^2 (2) = 10.43, p<.005).

T2: A discriminant function analysis was performed using the speech output tasks, AD: ABX, AD: same/different, RAPT (information and grammar score), to predict group membership (resolved and persisting). The independent variables were entered together and a significant Chi-square was uncovered, with 83% of cases (39/47) correctly classified (χ^2 (9) = 22.72, p<.01). The speech output tasks alone classified the same proportion, 83% (χ^2 (5) = 16.64, p<.005). The other measures also classified successfully: the auditory measures at 70.2% (χ^2 (2) = 15.13, p<.001) and the language measures at 74.5% (χ^2 (2) = 11.23, p<.05).

7.2.3. Summary of speech processing, language and nonverbal markers of speech outcome

Speech processing and language tasks differentiated the performance of children with resolved speech compared to children with persisting speech difficulties. On speech output tasks, the subgroups differed on all speech tests at all testing phases. On speech input tasks, children with resolved speech performed significantly better than children with persisting difficulties on AD: ABX at each testing phase and AD: same/different at T2. On language tasks, the resolved subgroup were significantly better on The Bus Story (information and MLU score) at T1 and RAPT (grammar score) at T2. At T3, differences were noted on an even greater range of tasks including receptive language tasks (Bus story MLU, RAPT information and grammar score, BPVS and TROG). Mean differences were noted earlier on most of these tasks, but these failed to reach significance. Language performance therefore differentiated the subgroups to a greater extent at T3 than earlier on in development.

7.2.4. Developmental, family and therapy markers of speech outcome

On the developmental and family questionnaires, small numbers precluded Chi-square analysis; Fisher's exact test is reported here where significance or near significance was found.

On the developmental questionnaire, only one significant finding was found: children with resolved speech were reported to have a higher incidence of asthma (Fisher's exact test, $p<.05$). The difference on incidence of feeding difficulties failed to reach significance (Fisher's exact test, $p = .08$). No differences were found on age when children were reported to say their first words ($U = 78$, ns). Children with persisting speech difficulties were, however, significantly later with first words than the controls (approximately, 9 months: $U = 150$, $p<.001$), whilst no difference was noted between the resolved subgroup and controls (approximately, 5.6 months: $U = 71.5$, $p =.08$). No significant difference was found of when the two clinical subgroups were reported to start walking ($U = 136$, ns).

On the family history questionnaire, no significant differences were found between subgroups, though two tests found near-significant levels: Father (own reading difficulties) (Fisher's exact test, $p = .07$) and Father (siblings' reading difficulties) (Fisher's exact test, $p = .09$).

Amount of therapy (and number of group or individual sessions) received was characterised by huge variability. However, significant differences were noted between speech outcome subgroups on number of group sessions received up till T1 ($U = 106.5$, $p<.01$), and number of group sessions received between T1 and T2 ($U = 96.5$, $p<.05$), but not between T2 and T3 ($U = 131.5$, ns). Significant differences were also noted on number of individual sessions up till T1 ($U = 126.5$, $p<.05$) and on individual sessions between T2 and T3 ($U = 67$, $p<.05$), but not between T1 and T2 ($U = 111$, ns). Children with persisting speech difficulties were receiving more speech and language therapy overall (measured in total minutes of therapy received, as measured by estimated length of session and number of sessions received) up till T1 ($U = 76.5$, $p<.01$) and between T2 and T3 ($U = 46$, $p<.01$) but not between T1 and T2 ($U = 59.5$, $p=.08$). The persisting speech subgroup was also more likely to be receiving regular therapy sessions (as opposed to being on review or on a waiting list) up until T1 (Fisher's exact $p<.005$) and between T1 and T3 (Fisher's exact $p<.001$) but not between T1 and T2. Another difference between the subgroups was also reflected in the larger number of children in the resolved subgroup (87.5% of this subgroup) who had been discharged by T3 (Fisher's exact test: $p<.05$) compared to 43.8% of the persisting subgroup. Of those children who were still receiving therapy between T2 and T3, more of the persisting speech subgroup was having phonological therapy (Fisher's $p<.05$) and phonological awareness therapy (Fisher's $p<.05$).

Three children in the persisting speech outcome subgroup were attending language units from or before T1. These children were receiving intensive input, which would have inflated the figures obtained for average numbers of sessions across the persisting speech subgroup. In order to evaluate the amount of therapy received by the majority of children, i.e. those attending community clinics, the means and SDs were calculated for children in community clinics up till T1. These are reported in Table 7.8. Children with persisting speech difficulties who were receiving therapy in a clinic had on average less than nine individual sessions for each time period. This was similar to the average of less than eight sessions reported for all children attending clinics, reported in Chapter 5. The number of group sessions diminished over time, from an average of six sessions (up till T1) to an average of just one group session between T2 and T3. Mann-Whitney tests showed that for those children attending community clinics, there were generally still significant differences of amount of therapy received according to outcome subgroup. On number of individual sessions, there were significant differences up till T1 ($U = 40$, $p<.05$) and between T2 and T3 ($U = 17$, $p<.01$), but not between T1 and T2 ($U =$

48, ns). Significant differences on number of group sessions was noted up till T1 ($U = 33.5$, $p<.05$) but not between T1 and T2 ($U = 36$, ns) and T2 and T3 ($U = 47.5$, ns).

The speech skills of the three children attending language units are reported in Table 7.9, together with the mean for the persisting speech subgroup, of which they were a part. A more intensive approach to therapy, which one might expect from a language unit setting, did not translate as more rapid gains in speech skills for two of the children. However, they appeared to have more severe speech difficulties initially, they had more pervasive speech/language problems and they were given this specialist provision, where others in the subgroup were not, suggesting they had a greater need. The remaining child (Child 3) did make rapid gains in her speech output skills between T1 and T2, though was still classified as having persisting speech difficulties at T3 as she scored below –1 SD on the composite speech output measure.

Table 7.5.
Developmental data by Speech outcome subgroup

Measure	Resolved speech subgroup (n=10)	Persisting speech subgroup (n=30)
	*% of yes responses	*% of yes responses
Birth & general health details		
Premature	30 (3/10)	12.5 (4/32)
Birth complications	0 (0/10)	12.9 (4/31)
Feeding difficulties	40 (4/10)	12.5 (4/32)
Allergies	0 (0/10)	19.4 (6/31)
Fits	0 (0/10)	0 (0/32)
Asthma	50 (5/10)	12.9 (4/31)
Frequent coughs and colds	50 (5/10)	21.9 (7/32)
Ear infections	20 (2/10)	25 (8/32)
Catarrh	0 (0/10)	9.4 (3/32)
Physical development		
**Age when first walked	12.1 (1.91)	13.34 (3.67)
Concerns over physical development	10 (1/10)	15.6 (5/32)
If yes, was:		
Treatment sought	100 (1/1)	100 (5/5)
If yes, was:		
Treatment given	100 (1/1)	80 (4/5)
Current problems	100 (1/1)	40 (2/5)
Hearing		
Concerns over hearing	40 (4/10)	37.5 (12/32)
If yes, was:		
Treatment sought	75 (3/4)	100 (11/11)
If yes, was:		
Treatment given	75 (3/4)	100 (11/11)
Current problems	0 (0/0)	9.1 (1/11)
Speech and language		
**Age of first words	18.63 (9.43)	22.5 (9.75)
Concerns over speech or language	100 (10/10)	96.9 (31/32)
If yes, was:		
Treatment sought	100 (10/10)	96.9 (31/32)
If yes, was:		
Treatment given	80 (8/10)	96.9 (31/32)
Current problems	40 (4/10)	45.2 (14/31)
Vision		
Concerns over vision	40 (4/10)	15.6 (5/32)
If yes, was:		
Treatment sought	100 (4/4)	100 (5/5)
If yes, was:		
Treatment given	100 (4/4)	80 (4/5)
Current problems	100 (4/4)	60 (3/5)
Other		
Right Handed	76.9 (10/13)	91.4 (32/35)

* unless otherwise stated
** mean and SD (months)

Table 7.6.

Family history data by Speech outcome subgroup

Mother's questionnaire		
Measure	**Resolved speech subgroup (n=10)**	**Persisting speech subgroup (n=30)**
	% of yes responses	**% of yes responses**
Reading difficulties (self)	20 (2/10)	6.7 (2/30)
Reading difficulties (parents)	10 (1/10)	20 (6/30)
Reading difficulties (grandparents)	0 (0/10)	3.3 (1/30)
Reading difficulties (siblings)	10 (1/10)	20 (6/30)
Reading difficulties (any family member)	30 (3/10)	32.3 (10/31)
Speech difficulties (self)	0 (0/10)	12.9 (4/31)
Speech difficulties (parents)	0 (0/10)	10 (3/30)
Speech difficulties (grandparents)	0 (0/10)	3.3 (1/30)
Speech difficulties (siblings)	0 (0/10)	13.3 (4/30)
Speech difficulties (any family member)	0 (0/10)	22.6 (7/31)
Attendance at speech therapy clinic (self)	0 (0/10)	10 (3/30)
Hearing loss (self)	0 (0/10)	13.3 (4/30)
Father's questionnaire		
Measure	**Resolved speech subgroup (n=8)**	**Persisting speech subgroup (n=24)**
	% of yes responses	**% of yes responses**
Reading difficulties (self)	22.2 (2/9)	0 (0/24)
Reading difficulties (parents)	12.5 (1/8)	12.5 (3/24)
Reading difficulties (grandparents)	0 (0/8)	4.2 (1/24)
Reading difficulties (siblings)	37.5 (3/8)	8.3 (2/24)
Reading difficulties (any family member)	50 (4/8)	16 (4/25)
Speech difficulties (self)	0 (0/9)	12.5 (3/24)
Speech difficulties (parents)	0 (0/8)	0 (0/23)
Speech difficulties (grandparents)	0 (0/8)	0 (0/23)
Speech difficulties (siblings)	0 (0/8)	4.3 (1/23)
Speech difficulties (any family member)	0 (0/8)	8.7 (2/23)
Attendance at speech therapy clinic (self)	11.1 (1/9)	8.3 (2/24)
Hearing loss (self)	12.5 (1/8)	8.3 (2/24)

Table 7.7.

Therapy questionnaire data by Speech outcome subgroup

	Up till T1: Mean (SD) (n=45)		T1-T2: Mean (SD) (n=44)		T2-T3: Mean (SD) (n=41)	
	Resolved	Persisting	Resolved	Persisting	Resolved	Persisting
Age of referral to SLT	3.38 (1.02)	2.80 (.82)				
No. of individual sessions	5.23 (5.78)	17.47 (30.58)	8.60 (20.35)	17.03 (37.40)	1.67 (4.64)	8.84 (14.11)
No. of group sessions	11.62 (38.61)	15.34 (35.70)	3 (9.49)	13.94 (37.80)	2 (4.44)	5.94 (16.64)
Total no. of minutes of therapy	953 (2505)	1210 (1411)	561 (1114)	1068 (1680)	42.78 (112.5)	586.5 (855)

	Up till T1		T1-T2		T2-T3	
	% of resolved	% of persisting	% of resolved	% of persisting	% of resolved	% of persisting
***Type of therapy:**						
Phonological	46.2 (6/13)	75 (24/32)	30 (3/10)	65.6 (21/32)	0 (0/9)	43.8 (14/32)
Oral motor skills	23.1 (3/13)	43.8 (14/32)	20 (2/10)	25 (8/32)	0 (0/9)	12.5 (4/32)
Articulatory	15.4 (2/13)	18.8 (6/32)	20 (2/10)	46.9 (15/32)	11.1 (1/9)	40.6 (13/32)
Phonological awareness	30.8 (4/13)	56.3 (6/32)	30 (3/10)	58.1 (18/31)	0 (0/9)	46.9 (15/32)
Expressive language	7.7 (1/13)	25 (8/32)	0 (0/10)	15.6 (5/32)	11.1 (1/9)	28.1 (9/32)
Receptive language	7.7 (1/13)	18.8 (6/32)	10 (1/10)	9.4 (3/32)	0 (0/9)	9.4 (3/32)
Play skills	0 (0/13)	6.3 (2/32)	0 (0/10)	0 (0/32)	0 (0/9)	0 (0/32)
Listening skills	15.4 (2/13)	46.9 (15/32)	10 (1/10)	25 (8/32)	0 (0/9)	15.6 (5/32)
Social skills	7.7 (1/13)	6.3 (2/32)	10 (1/10)	6.3 (2/32)	0 (0/9)	6.3 (2/32)
Parent workshop	7.7 (1/13)	25 (8/32)	0 (0/10)	0 (0/32)	0 (0/9)	0 (0/32)
Parent-child interaction	7.7 (1/13)	12.5 (4/32)	10 (1/10)	3.1 (1/32)	0 (0/9)	0 (0/32)
Other	15.4 (2/13)	3.1 (1/32)	20 (2/10)	9.4 (3/32)	11.1 (1/9)	0 (0/32)
Therapy setting:						
Clinic	77.8 (7/9)	80.6 (25/31)	70 (7/10)	69.7 (23/33)	22.2 (2/9)	62.5 (20/32)
School	0 (0/9)	0 (0/31)	0 (0/10)	3 (1/33)	0 (0/9)	3.1 (1/32)
Language Unit	11.1 (1/9)	0 (0/31)	0 (0/10)	9.1 (3/33)	0 (0/9)	9.4 (3/32)
Hospital	0 (0/9)	3.2 (1/31)	0 (0/10)	0 (0/33)	0 (0/9)	0 (0/32)
Combination of settings	11.1 (1/9)	16.1 (5/31)	10 (1/10)	3 (1/33)	0 (0/9)	0 (0/32)
Specialist centre	0 (0/9)	0 (0/31)	0 (0/10)	0 (0/33)	11.1 (1/9)	0 (0/32)
Frequency of liaison:						
Yearly	33.3 (3/9)	20 (6/30)	0 (0/10)	6.5 (2/31)	0 (0/9)	3.1 (1/32)
Termly	0 (0/9)	6.7 (2/30)	0 (0/10)	29 (9/31)	0 (0/9)	31.3 (10/32)
Occasionally	0 (0/9)	43.3 (13/30)	20 (2/10)	38.7 (12/31)	0 (0/9)	18.8 (6/32)
None	55.6 (5/9)	23.3 (7/30)	70 (7/10)	16.1 (5/31)	100 (9/9)	37.5 (12/32)
Ongoing	11.1 (1/9)	6.7 (2/30)	10 (1/10)	9.7 (3/31)	0 (0/9)	9.4 (3/32)
***Management:**						
Regular for therapy	40 (4/10)	90.3 (28/31)	62.5 (5/8)	78.8 (26/33)	0 (0/9)	68.8 (22/32)
On review	10 (1/10)	45.2 (14/31)	25 (2/8)	24.2 (8/33)	11.1 (1/9)	34.4 (11/32)
On waiting list	50 (5/10)	32.3 (10/31)	25 (2/8)	3 (1/33)	0 (0/9)	3.1 (1/32)
Planned discharge						
Discharged	0 (0/10)	0 (0/31)	44.4 (4/9)	21.2 (7/33)	87.5 (7/8)	43.8 (14/32)
Statementing:						
Statemented	10 (1/10)	9.7 (3/31)	10 (1/10)	6.3 (2/32)	0 (0/8)	12.9 (4/31)
Stage 1	0 (0/10)	0 (0/31)	0 (0/10)	3.1 (1/32)	0 (0/8)	6.5 (2/31)
Stage 2	0 (0/10)	0 (0/31)	0 (0/10)	6.3 (2/32)	0 (0/8)	3.2 (1/31)
Stage 3	0 (0/10)	9.7 (3/31)	0 (0/10)	6.3 (2/32)	0 (0/8)	12.9 (4/31)
Stage 4	0 (0/10)	0 (0/31)	0 (0/10)	0 (0/32)	0 (0/8)	0 (0/31)
Involvement of other agencies	10 (1/10)	40.6 (13/32)	20 (2/10)	18.8 (6/32)	11.1 (1/9)	16.7 (5/30)

* not mutually exclusive categories

Table 7.8.
Therapy questionnaire data by Speech outcome subgroup: Average session times of children reported to be attending a community clinic up till T1

	Up till T1: Mean (SD)		T1-T2: Mean (SD)		T2-T3: Mean (SD)	
	Resolved (n=7)	Persisting (n=25)	Resolved (n=7)	Persisting (n=25)	Resolved (n=7)	Persisting (n=25)
No. of individual sessions	2.86 (3.29)	8.96 (8.81)	2.33 (2.88)	7.72 (10.21)	0 (0)	5.67 (6.98)
No. of group sessions	.71 (1.89)	6.16 (6.37)	0 (0)	2.92 (4.32)	0 (0)	1.42 (3.41)
Total no. of minutes of therapy	229.29 (182.63)	768 (619.8)	120 (162.48)	586.9 (496.1)	0 (0)	335.8 (460.5)

Table 7.9.
Z-scores on composite output measure of 3 children attending language units

	Child1	Child 2	Child 3	Persisting speech subgroup
Output T1 (z-score)	-9.04	-7.58	-8.65	-7.24 (2.36)
Output T2 (z-score)	-14.25	-10.42	-2.03	-6.24 (4.23)
Output T3 (z-score)	-4.47	-4.22	-1.41	-2.72 (1.81)

Note: Z-score was calculated using the Control group's mean and SD

7.2.5. Psychosocial information

Mann-Whitney tests were used to compare ratings on each psychosocial scale and on the total SDQ score between subgroups. Ratings ranged from 0-10 for each subtest, and from 0-40 for the total difficulties scale excluding prosocial behaviour (see Table 7.10 for means and SDs). A significant subgroup difference was found between those with resolved speech and those with persisting speech difficulties on the Hyperactivity scale ($U = 115$, $p<.05$). All other comparisons were not significant (Emotional symptoms: $U = 191.5$, ns; Conduct problems: $U = 189$, ns; Peer problems: $U = 168$, ns; Prosocial behaviour: $U = 190$, ns; Total difficulties score: $U = 149.5$, ns). Table 7.11 shows the percentage of children by subgroup showing a normal profile, borderline problems or difficulties as defined by Goodman (1997) and described in Chapter 5, section 5.2.4.

Table 7.10.
Mean performance on Strengths and Difficulties Questionnaire (SDQ) scales by Speech outcome subgroup

	Resolved speech subgroup (n=12)	Persisting speech subgroup (n=33)
Emotional symptoms	2.25 (1.91)	2.55 (2.46)
Conduct problems	.58 (1.24)	.48 (1.25)
Hyperactivity	1.75 (2.63)	3.91 (3.10)
Peer problems	1 (1.21)	1.67 (2.07)
Prosocial behaviour	7.33 (2.42)	7.67 (2.06)
Total difficulties	5.58 (4.25)	8.61 (6.38)

Note: SDs in parentheses

Table 7.11.
Classification on Strengths and Difficulties Questionnaire (SDQ) scales by percentage of children in Speech outcome subgroups

	% of Resolved speech subgroup (n=12) (n in parentheses)			% of Persisting speech subgroup (n=33) (n in parentheses)		
	Normal	Borderline	Difficulties	Normal	Borderline	Difficulties
Emotional symptoms	83.3 (10)	16.7 (2)	0 (0)	75.8 (25)	12.1 (4)	12.1 (4)
Conduct problems	91.7 (11)	0 (0)	8.3 (1)	90.9 (30)	0 (0)	9.1 (3)
Hyperactivity	91.7 (11)	0 (0)	8.3 (1)	63.6 (21)	18.2 (6)	18.2 (6)
Peer problems	100 (12)	0 (0)	0 (0)	78.8 (26)	15.2 (5)	6.1 (2)
Prosocial behaviour	75 (9)	16.7 (2)	8.3 (1)	75.8 (25)	18.2 (6)	6.1 (2)
Total difficulties	91.7 (11)	8.3 (1)	0 (0)	63.6 (21)	21.2 (7)	15.2 (5)

7.2.6. Rate of change as a developmental marker of speech outcome

Rate of change was calculated by speech outcome subgroup on measures of speech output, speech input, language and nonverbal skills (see Tables 7.12- 7.14). Children in both outcome groups made significant progress on word and nonword repetition tasks throughout the study. They showed similar gains between T1 and T2. Between T2 and T3, the persisting speech subgroup showed greater gains on LF word repetition pcc but similar mean gains on LF nonword repetition pcc. The persisting speech subgroup made similar significant gains to the resolved group on articulatory naming between T1 and T2. Between T2 and T3, the resolved speech subgroup did not make significant improvement on articulatory naming between T2 and T3, whilst the persisting speech subgroup did. On language tasks, there was evidence of plateauing skills/ceiling effects on RAPT for the resolved speech subgroup. The persisting speech subgroup showed significant improvements on all measures throughout the study. On speech input tasks, comparison was not made between AD: ABX T1-T2 nor between

AD: picture task T2-T3, as these tasks had been modified. Neither subgroup made significant improvements on the AD: same/different task. The resolved speech subgroup made no improvement on the AD: ABX task between T2 and T3, whilst the persisting subgroup did.

Differing development of speech skills by subgroup relative to controls was then examined. In Chapter 4, it was found that the majority of children in the speech disordered group showed a greater increase in scores between T1 and T2 than controls. Between T2 and T3, the pattern of change was more varied, with some showing similar change to controls, others continuing to show greater change, whilst others showed less improvement. Whether these patterns are mediated by speech outcome can now be explored.

Table 7.15 reports the percentage of children showing similar, greater or less change relative to controls, by speech outcome subgroup on speech output tasks. Rates are shown between T1 and T2, and between T2 and T3. Comparison was made by calculating the controls' z-score changes between testing phases (T1-T2, T2-T3) and examining the speech disordered group's z-score change relative to this (see Chapter 4, section 4.2.4.6, for further details).

Table 7.12.
Mean changes and SDs over time on word and nonword repetition and articulatory naming by Speech outcome subgroup

Test and time comparison	Resolved speech subgroup		Persisting speech subgroup	
	Mean pcc change	T-value (12)	Mean pcc change	T-value (33)
T1-T2 Word pcc	29.97 (4.54)	-23.78**	29.64 (16.33)	-10.59**
T1-T2 Nonword pcc	29.77 (6.33)	-15.82**	25.78 (15.25)	-9.86**
T1-T2 Articulatory naming pcc	23.33 (12.12)	-6.94	22.87 (13.02)	-10.25**
T2-T3 LF word pcc	8.54 (7.26)	-4.24**	17.98 (14.81)	-7.08**
T2-T3 LF nonword pcc	10.20 (5.82)	-6.32**	10.45 (13.23)	-4.60**
T2-T3 Articulatory naming pcc	3.55 (10.40)	-1.23	11.84 (13.96)	-4.95**

Note: SDs in parentheses
** Significant difference between testing phases (T-test) at p<.001

Table 7.13.
Changes over time on language and nonverbal tasks by Speech outcome subgroup: T-test results

Test and time comparison	Resolved speech subgroup	Persisting speech subgroup
	T-value (12)	T-value (33)
T1-T2 Bus Story (information score)	-1.48	-8.12***
T2-T3 Bus Story (information score)	-2.90*	-4.89***
T1-T2 Bus Story (MLU score)	-2.20*	-8.22***
T2-T3 Bus Story (MLU score)	-3.59**	-3.91***
T1-T2 RAPT (information score)	-6.83**	-5.59***
T2-T3 RAPT (information score)	-1.70	-4.35***
T1-T2 RAPT (grammar score)	-5.86**	-7.43***
T2-T3 RAPT (grammar score)	-.64	-3.04**
T1-T2 Naming	-4.69***	-6.79***
T2-T3 Naming	-4.32***	-4.94***
T1-T2 BPVS	-5.81***	-9.06***
T2-T3 BPVS	-4.32***	-4.94***
T1-T2 TROG (no. of items)	-4.5***	-6.63***
T2-T3 TROG (no. of items)	-3.43**	-5.86***
T1-T3 Block design (ss)	-2.25*	-3.30**
T1-T3 Picture completion (ss)	-4.81***	-8.03***

Asterisks indicate significant differences between testing phases (T-tests): *** p<.001 **p<.01 *p<.05

Table 7.14.
Changes over time on speech input tasks by Speech outcome subgroup: T-test results

Test and time comparison	Resolved speech subgroup	Persisting speech subgroup
	T-value (12)	T-value (33)
T1-T2 AD: picture task	-3.41**	-4.52***
T2-T3 AD: ABX task	-2.16	-3.63**
T1-T2 AD: S/D task	-2.13	-1.99

Asterisks indicate significant differences between testing phases (T-tests): *** p<.001**p<.01*p<.05

Table 7.15.
Comparison of rates of change of the Speech outcome subgroups in relation to the Control group on speech output tasks

	Similar change		Greater change		Less change	
T1-T2	% of Resolved subgroup	% of Persisting subgroup	% of Resolved subgroup	% of Persisting subgroup	% of Resolved subgroup	% of Persisting subgroup
Word repetition	0% (0)	14.7% (5)	100% (13)	85.3%(29)	0% (0)	0% (0)
Nonword repetition	0% (0)	20.6% (7)	100% (13)	79.4% (27)	0% (0)	0% (0)
Articulatory naming	15.4% (2)	29.4% (10)	84.6% (11)	70.6% (24)	0% (0)	0% (0)
T2-T3						
Word repetition	53.8% (7)	23.5% (8)	46.2% (6)	73.5% (25)	0% (0)	2.9% (1)
Nonword repetition	46.2% (6)	41.2% (14)	53.8% (7)	47.1% (16)	0% (0)	11.8% (4)
Articulatory naming	53.8% (7)	29.4% (10)	30.8% (4)	61.8% (21)	15.4% (2)	8.8% (3)

Number in brackets
Note: Similar change = within 1 SD of the Control group's change in performance between testing phases
Greater change = more than +1 SD of the Control group's change in performance between testing phases
Less change = more than –1 SD of the Control group's change in performance between testing phases

Between T1 and T2, no children in either speech outcome subgroup showed less change relative to controls on any of the speech output tasks. More of the resolved subgroup showed greater change compared to the persisting speech subgroup (Word repetition: χ^2 (1) = 6.1, p<.01; Nonword repetition: χ^2 (1) = 4.9, p<.05; and Articulatory naming: χ^2 (1) = 4.83, p<.05). This pattern was reversed between T2 and T3 on Word repetition and Articulatory naming, with more of the persisting speech subgroup showing greater change compared to the resolved speech subgroup (Word repetition: χ^2 (1) = 11.65, p<.001; Articulatory naming χ^2 (1) = 11.56, p<.001). On Word repetition, approximately half of the resolved subgroup showed more growth, whilst the other half showed similar rates of change to controls. On Articulatory naming, two children in the resolved subgroup actually showed less change than controls, a pattern observed in three children in the persisting speech subgroup. On Nonword repetition, a slightly different pattern is observed, with similar proportions of children in each subgroup showing greater change (χ^2 (1) = 3.52, p=.06). Fewer children with persisting problems showed improvement on this task. Indeed, four children with persisting problems actually showed less improvement. These results indicate a different pattern of change in word and nonword repetition, which is explored in the following section.

7.2.7. Word/nonword discrepancy: changes over time

Table 7.16 reports the average discrepancy between word and nonword performance by subgroup at each testing phase for the original version of the word/nonword test and the extended version, which used low frequency words and matched nonwords. Discrepancy refers to the difference in scores between word and nonword repetition. For the resolved speech subgroup, there was no significant change in the discrepancy between the two tasks for both versions over time (original version, T1-T2: $Z = -1.08$, ns; LF version, T2-T3: $Z = -1.43$, ns). This mirrors the pattern in the control group (original version, T1-T2: $Z = -1.07$, ns; LF version, T2-T3: $Z = -.41$, ns). This pattern was not replicated for the persisting speech subgroup. For this subgroup, the discrepancy was found to increase significantly over time (original version, T1-T2: $Z = -2.44$, $p<.05$; LF version, T2-T3: $Z = -3.31$, $p<.001$). Inspection of the raw scores for percentage of consonants correct on word and nonword repetition show that the persisting speech subgroup, whilst making significant gains on these tasks, are actually making less rapid gains on nonword repetition compared to word repetition between T1 and T2 and between T2 and T3.

Table 7.16.
Means and SDs of word/nonword discrepancies by Speech outcome subgroups

	Resolved speech subgroup (n=13)	Persisting speech subgroup (n=34)	Controls (n=47)
Discrepancy between word and nonword repetition (pcc) T1	1.5 (3.47)	.84 (6.71)	2.01 (4.49)
Discrepancy between word and nonword repetition (pcc) T2	3.7 (5.03)	4.7 (7.11)	3.40 (4.86)
Discrepancy between LF word and nonword repetition (pcc) T2	9.11 (5.09)	5.09 (8.14)	7.28 (6.96)
Discrepancy between LF word and nonword repetition (pcc) T3	7.45 (4.7)	12.62 (7.18)	6.8 (6.98)

Note: SDs in parentheses

7.2.8. Establishing a severity threshold on speech output tasks

Analyses reported in Section 7.2 found significant differences between the resolved and persisting subgroups on speech processing and language tasks. In particular, children with persisting speech difficulties had more severe speech difficulties throughout the course of the study. In this section, performance on speech tasks is analysed to examine whether the severity of a speech problem or the pervasiveness of a child's speech/language profile is more closely related to outcome. Also an examination is made of whether there is a threshold or level of severity of speech difficulty that differentiates the subgroups.

First, the relationship between pervasiveness at T1 and outcome at T3 was analysed using the speech/language subgroup classification of Chapter 6. This is reported in Table 7.17 and shows that children with a pervasive speech and language difficulty are more likely to have persisting difficulties than resolving difficulties. Only two children with speech and language difficulties resolved. For children with specific speech difficulties, the relationship with outcome was less clear. More children in this subgroup fell into the resolved speech subgroup, but a significant number had persisting speech problems.

In order to compare a competing hypothesis that severity of the speech difficulty, rather than pervasiveness of the speech/language profile is central to later speech outcome, a median split of word repetition at T1 was calculated (53.25%), of the speech disordered group's scores (percentage of consonants correct). Results in relation to outcome are also reported in Table 7.17. This shows that a more severe deficit at T1 resulted in a high likelihood of persisting speech problems, with only one child who had such severe deficits going on to resolve in their speech difficulties. For those in the less severe speech category at T1, half resolved in their speech, and the other half showed persisting speech difficulties. Both analyses (by pervasiveness and by severity) showed a similar pattern of performance. A more pervasive or a more severe difficulty at T1 was associated with a poorer outcome. However, a specific or a less severe speech difficulty found a less clear-cut distinction on outcome, with some resolving and some showing persisting problems.

Table 7.17.
Relationship between pervasiveness and severity at T1 and speech outcome at T3: Percentage of children with resolved and persisting speech problems according to pervasive/specific difficulties and according to severe/less severe difficulties at T1

Outcome status at T3	Pervasiveness dimension at T1		Severity dimension at T1	
	% Speech-only (n=28)	% Speech/language (n=19)	% Less Severe (n=24)	% Severe (n=23)
Resolved at T3	39.3% (11)	10.5% (2)	50% (12)	4.3% (1)
Persisting at T3	60.7% (17)	89.5% (17)	50% (12)	95.7% (22)

Level of performance on speech output tasks was also examined retrospectively in order to identify whether there was a clear differentiation in terms of severity between the speech outcome groups classified at T3. For each speech output task, the level of accuracy was identified above which all children in the resolved speech subgroup scored. Then the percentage of children in the persisting speech subgroup who fell below this threshold of performance was calculated. The threshold for each test and the percentage of children with persisting speech difficulties who scored lower than this threshold are reported in Table 7.18. The level above which the resolved subgroup scored differs for each test, and is higher at T2 when their speech skills are already improved. At T1, the majority of children with persisting speech difficulties are falling below the threshold, except for articulatory naming. This shows most are differentiated by absolute level of performance, but a significant proportion fall within a similar level of severity of difficulty as the resolved speech subgroup. At T2, there is increasing overlap, with many children scoring above the threshold.

These two analyses show that severity can account for some of the variation in outcome in the speech disordered group, but a threshold cannot be clearly defined that would predict later performance. Pervasiveness of the initial speech/language difficulty looks to be as valid in its relationship to outcome, and this is explored in more detail in the next section.

Table 7.18.
Severity threshold by Speech outcome subgroup

Test	Severity threshold	% Persisting speech subgroup scoring below this threshold
T1		
E.A.T.	Ss 70	76.5 (26/34)
Word repetition	50 pcc	58.8 (20/34)
Nonword repetition	45 pcc	61.8 (21/34)
Articulatory naming	38 pcc	38.2 (13/34)
T2		
Word repetition	75 pcc	44.1 (15/34)
Nonword repetition	65 pcc	32 (11/34)
LF word repetition	67 pcc	58.8 (20/34)
LF nonword repetition	60 pcc	50 (17/34)
Articulatory naming	72 pcc	47.1 (16/34)

pcc = percentage of consonants correct

7.2.9. Pervasive difficulty as a clinical marker of speech outcome

Subgroup differences were found across a range of measures and it is hypothesised that speech outcome is related to how pervasive the speech and language problem is. Some evidence was found in the last section to support this view and in the analyses in Chapter 6, which found a relationship between having additional language difficulties, problems in speech input processing and lower levels of speech output at T3. In this section, the issue of pervasive difficulties will be examined more closely through a classification that takes account of associations and dissociations between speech output, speech input and language measures, as shown in Tables 7.19 and 7.20. The percentage of children in each outcome subgroup was calculated according to speech output/speech input/language profile at T1, i.e. whether children with speech difficulties scored less well than controls on speech output, speech input and/or language skills. A –1 SD cut-off on composite measures of these skills was used.

Children with persisting speech difficulties at T1 were more likely to have a profile of pervasive difficulties compared to children with resolved difficulties. Children classified as resolved were more likely to have specific speech difficulties with other skills spared at T1 (76.9% of this subgroup). However, a significant proportion of children with persisting speech difficulties did not have a pervasive profile of difficulties but had specific speech output problems at T1, i.e. 38% of this subgroup. Persisting speech problems can therefore occur in the absence of a pervasive profile at T1. This is illustrated in the Venn diagram in Figure 7.1, which shows a distinct pattern: children with resolving difficulties fall into the speech output difficulties circle only; some children with persisting speech difficulties also fall within this circle, but others fall within overlapping circles.

Table 7.20 illustrates that pervasiveness is related to severity of the speech problem. For word and nonword repetition, the more pervasive the problem, the more severe the speech problem. For articulatory naming, the most pervasive profile is related to a poorer performance, whilst the first three categories show more similar levels of performance.

Individual analysis of the 13 children with specific but persisting speech output difficulties at T1 revealed later emerging difficulties. Of these 13 children, five showed associated difficulties at T3: four had speech input difficulties at T3, and one had language difficulties at T3. This leaves eight children with specific, persisting speech difficulties who do not exhibit other 'at risk' signs, such as delayed language skills or speech input deficits.

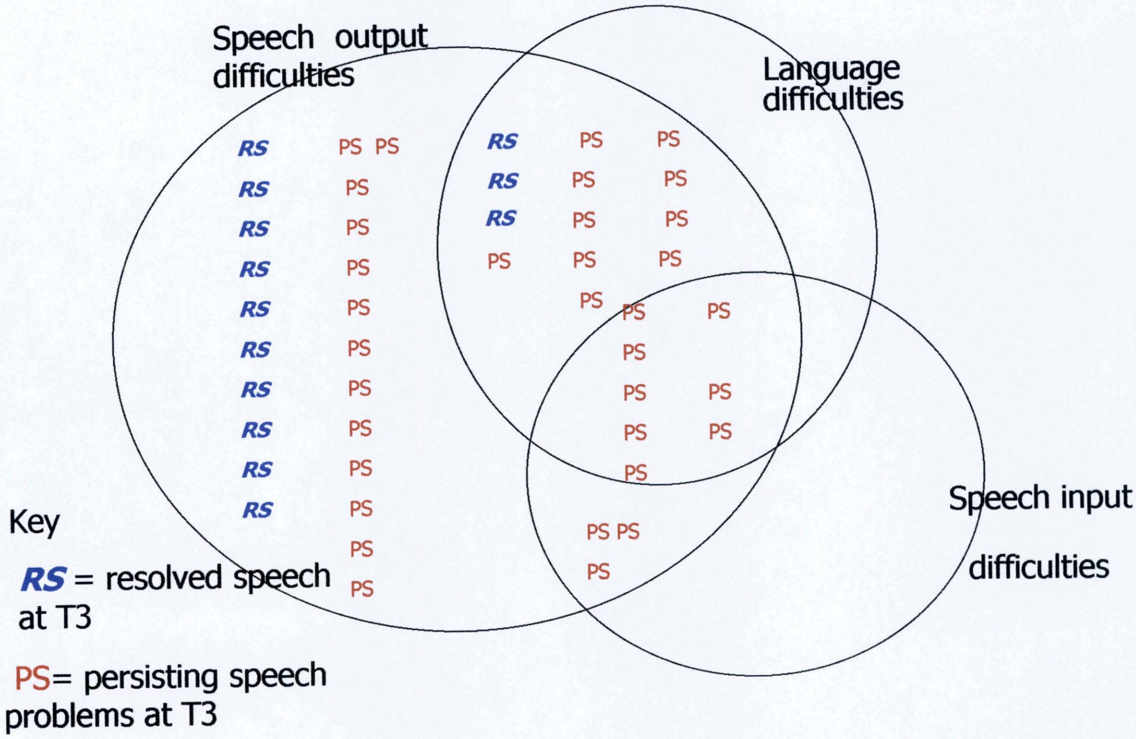
Table 7.19.
Profiles of speech/language performance at T1 and their relationship to Speech outcome subgroup

Status at T1 (pervasiveness)			Total: Speech disordered (n=47)	Resolved at T3 (n=13)	Persisting at T3(n=
Speech output	Speech input	Language	% (n in parentheses)	% (n in parentheses)	% (n in parentheses
x	✓	✓	51 (24)	76.9 (10)	38.2 (13)
x	✓	x	25.5 (12)	23.08 (3)	29.4 (10)
x	x	✓	6.4 (3)	0 (0)	8.8 (3)
x	x	x	17.02 (8)	0 (0)	23.5 (8)

Table 7.20.
Profiles of speech/language performance at T1 and their relationship to speech severity at T3

Status at T1			Speech severity at T3		
Speech output	Speech input	Language	LFWRep pcc	LFNWRep pcc	Naming pcc
x	✓	✓	86.63 (6.86)	76.09 (9.94)	87.28 (6.74)
x	✓	x	79.26 (10.95)	67.71 (13.79)	85.12 (6.70)
x	x	✓	73.56 (9.74)	64.12 (14.96)	83.45 (3.83)
x	x	x	65.09 (18.60)	52.32 (14.74)	69.32 (16.77)

Figure 7.1.
Venn Diagram showing patterns of deficits at T1 and their relationship to speech outcome at T3



7.2.10. Specific speech difficulties: resolved vs. persisting

The performance of the children with specific, but persisting difficulties was analysed further and compared to the resolved subgroup. There were eight children who had speech-only problems whose difficulties did not resolve (and also did not exhibit any later emerging speech input or language measures) and ten children who had speech-only problems at the beginning of the study whose difficulties resolved. Mean scores and SDs on speech output tasks by these two subgroups are reported in Table 7.21. Means indicate that children with specific and persisting speech problems start off at T1 with more severe speech difficulties than the children whose problems resolve. The table also indicates means and SDs for a subgroup of eight children identified in Table 7.19 with pervasive problems of speech output, speech input and language. These children all had persisting problems. It is noted that these children are, at all times during the study, and on all speech output tests, more severely impaired than the children with isolated and persisting problems.

This relationship between severity and pervasiveness in this subgroup was demonstrated further by examining speech performance in terms of quartile ranges. One low performing outlier with pervasive difficulties was excluded as this might have distorted results by showing greater severity in the pervasive and persisting subgroup. The quartile ranges were calculated for word repetition at T3 using the pcc scores of the speech disordered group. This found that only one of the eight children (12.5%) with isolated/persisting speech difficulties fell in the fourth (lowest scoring) quartile, with the remaining seven in the second/third (mid-range) quartiles. In contrast, 5/8 (62.5%) of those with persisting and pervasive difficulties were in the fourth (lowest scoring) quartile, with the remaining three (37.5%) in the third (mid-range) quartile.

7.2.11. Specific vs. pervasive difficulties: word/nonword performance over time

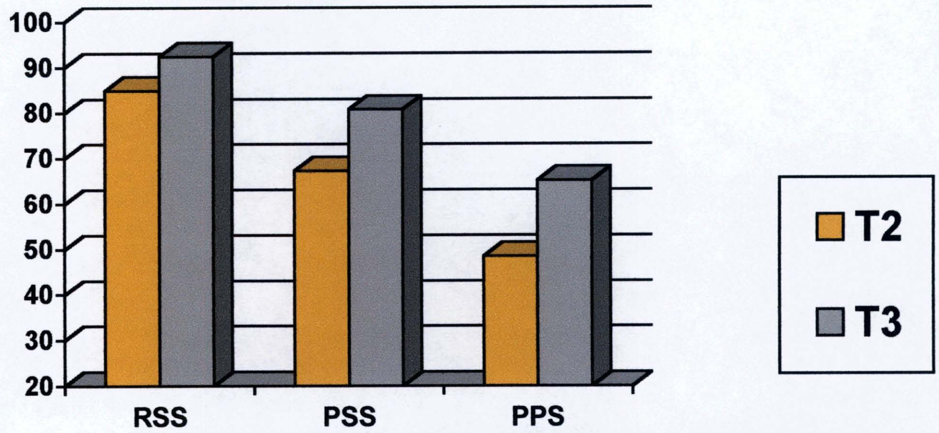
The performance of word/nonword repetition over time was examined for the three subgroups of children (resolved specific, persisting specific and persisting pervasive). First, changes between T1 and T2 were examined. Although numbers in these subgroups were small, nonparametric statistics (Wilcoxon Signed Ranks Test) were calculated to explore changes over time. The three subgroups made significant progress between T1 and T2 on the original version of the Word repetition task (resolved specific: $Z = -2.8$, $p<.005$; persisting specific: $Z = -2.52$, $p<.05$; persisting pervasive: $Z = -2.53$, $p<.05$). Similar improvement was noted on Nonword repetition (resolved specific: $Z = -2.8$, $p<.005$; persisting specific: $Z = -2.52$, $p<.05$; persisting pervasive: $Z = -2.52$, $p<.05$). It was noted that the results for the resolved specific subgroup showed a greater degree of difference (higher significance level) than the other two subgroups.

Then the changes between T2 and T3 on the Extension version of the repetition task were examined. The two subgroups of children with persisting problems made less progress on LF nonword repetition between T2 and T3 than those in the subgroup whose speech resolves. Both children with resolved specific difficulties and persisting specific difficulties made significant progress between T2 and T3 on LF word repetition (resolved specific: $Z = -2.8$, $p<.005$; persisting specific: $Z = -2.24$, $p<.05$). However, only the resolved specific subgroup made progress between T2 and T3 on LF nonword repetition (resolved specific: $Z = -2.8$, $p<.005$; persisting specific: $Z = -1.4$, ns). Children with pervasive speech output, speech input and language difficulties whose problems persisted followed a similar pattern to those with isolated/persisting problems by showing improvement on word but not nonword repetition between T2 and T3 (LF word repetition: $Z = -2.1$, $p<.05$; LF nonword repetition: $Z = -1.12$, ns). These results are illustrated in the Bar charts of Figures 7.2 and 7.3, which show significant improvements made on word repetition for all three subgroups, compared to significant improvements only for the resolved subgroup on nonword repetition. These results seem at odds with those reported in section 7.2.6. where children with persisting speech difficulties were shown to make significant improvement on nonword repetition between T2 and T3, though less rapid gains than on word repetition. The analyses here, exploring performance with *subsets* of this subgroup, found that there was no significant improvement between T2 and T3 on nonword repetition for children with isolated speech problems, and those children with the most pervasive problems. The subdivision of subgroup may have reduced power, so that significant differences were not found. Nonetheless, a significant difference was found on the group of ten children with resolved specific difficulties, showing that an argument for lack of power may not be sufficient to explain the results. In addition, the mean change of nonword repetition between T2 and T3 for these smaller subgroups with persisting problems is smaller (5.52 pcc for the persisting specific, 6.67 pcc for the persisting pervasive) than the mean change for the bigger, persisting speech subgroup (10.45 pcc)

Table 7.21.
Comparison of children with isolated speech difficulties at T1 that resolved and children with isolated speech difficulties or pervasive difficulties at T1 that persisted

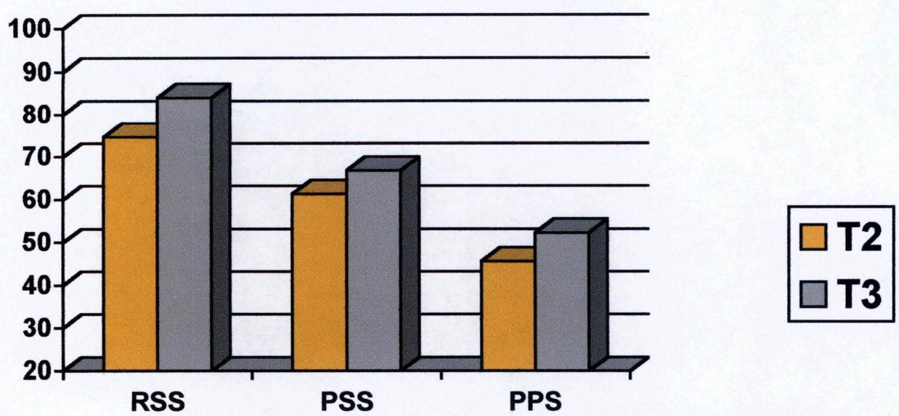
	Resolved specific speech difficulties (n=10)	Persisting specific speech difficulties (n=8)	Persisting pervasive speech difficulties (n=8)
T1			
EAT ss	76.80 (5.05)	69.88 (13.36)	53.25 (10.08)
Word repetition pcc	64.29 (7.75)	52.60 (14.18)	34.58 (11.38)
Nonword repetition pcc	62.21 (7.13)	51.30 (13.09)	33.28 (10.13)
Articulatory naming pcc	65.21 (13.63)	58.04 (10.78)	33.41 (12.94)
T2			
Word repetition pcc	93.9 (6.82)	86.69 (11.12)	62.82 (24.05)
Nonword repetition pcc	89.74 (10.65)	82.79 (9.1)	57.79 (23.03)
Articulatory naming pcc	86.51 (8.96)	76.23 (10.74)	60.75 (18.18)
LF word repetition pcc	84.89 (9.29)	67.26 (15.14)	48.47 (20.09)
LF nonword repetition pcc	74.67 (9.35)	61.35 (14.53)	45.65 (17.52)
T3			
LF word repetition pcc	92.4 (3.94)	80.71 (6.53)	65.09 (18.60)
LF nonword repetition pcc	84.03 (5.54)	66.87 (6.21)	52.32 (14.74)
Articulatory naming pcc	90.58 (5.26)	85.27 (7.27)	69.32 (16.77)

Figure 7.2.
Bar Chart of mean scores of Word repetition T2 vs T3 by resolved and persisting speech difficulties



RSS=resolved specific speech difficulty
PSS=persisting specific speech difficulty
PPS=pervasive and persisting difficulties

Figure 7.3.
Bar Chart of mean scores of Nonword repetition T2 vs T3 by resolved and persisting speech difficulties



RSS=resolved specific speech difficulty
PSS=persisting specific speech difficulty
PPS=pervasive and persisting difficulty

7.2.12. Word length effects on LF word/nonword repetition

In the last section, it was noted that children with persisting speech difficulties (either specific problems, or pervasive problems) show an increasing discrepancy between word and nonword repetition and a lack of improvement on nonword repetition between T2 and T3. It will be argued that this reveals a problem with the ability of these children to form accurate motor programs for new words. Although an increasing discrepancy was found between T1 and T2 for the subgroup of children with persisting difficulties, this discrepancy was not as great as the one that emerged between T2 and T3 on the Extension tasks. Furthermore, the analyses in the previous section with the smaller subgroups did not reveal differences in improvement between T1 and T2 on word and nonword repetition.

Whilst there is thus some indication of an increasing discrepancy earlier on, the results do not show a gradual and consistent pattern of increasing word/nonword repetition discrepancy. One reason for this could be the use of different repetition tasks: the original repetition tasks, using highly familiar words (and matched nonwords) in sets of 1, 2, 3/4 syllables; and, the extension repetition tasks, using low frequency words (and matched nonwords) in sets of 1-5 syllables. Referring back to Table 7.1, it is apparent that levels of accuracy were different across tasks at T2, when both tasks were administered. The effect of word frequency may account for these differences. It is also possible that the differences in word length between these two tasks could be a factor influencing performance. Children with persisting speech problems may have the greatest difficulty on longer words/nonwords. This section explores whether the lack of improvement on nonword repetition between T2 and T3 was across all word lengths or confined to longer stimuli.

Means and SDs are reported in Tables 7.22-7.24 for each subgroup. Wilcoxon Signed Ranks test found that the resolved specific speech subgroup only made significant improvements between T2 and T3 on longer stimuli (1-syllable: $Z = -1.81$, ns; 2-syllable: $Z = -1.38$, ns; 3-syllable: $Z = -.50$, ns; 4-syllable: $Z = -2.66$, $p<.01$; 5-syllable: $Z = -2.40$, $p<.05$). The persisting specific speech subgroup only made significant improvement on 1-syllable nonwords (1-syllable: $Z = -2.2$, $p<.05$; 2-syllable: $Z = -.54$, ns; 3-syllable: $Z = -.09$, ns; 4-syllable: $Z = -1.58$, ns; 5-syllable: $Z = -.42$, ns).

The persisting speech subgroup made no significant improvement across syllable length (1-syllable: $Z = -1.63$, ns; 2-syllable: $Z = -1.67$, ns; 3-syllable: $Z = -.68$, ns; 4-syllable: $Z = -.99$, ns; 5-syllable: $Z = -1.75$, ns).

There is some indication that improvement is more likely in shorter nonwords than longer nonwords for the persisting specific speech subgroup, but for the persisting pervasive speech subgroup, no effect of length is apparent. For the resolved specific speech subgroup, improvement is made on longer nonwords, whilst the persisting subgroup's performance does not shift significantly.

Table 7.22.
Means and SDs of LF nonword repetition by syllable length: Resolved specific speech subgroup

No. of syllables	LF nonword repetition T2	LF nonword repetition T3
1	83.85 (12.27)	92.31 (8.11)
2	86 (10.16)	90.67 (5.62)
3	82.67 (13.41)	85.33 (13.63)
4	66.52 (6.50)	80.87 (10.29)
5	66.15 (14.37)	78.08 (11.76)

Note: SDs in parentheses

Table 7.23.
Means and SDs of LF nonword repetition by syllable length: Persisting specific speech subgroup

No. of syllables	LF nonword repetition T2	LF nonword repetition T3
1	69.23 (16.45)	81.73 (7.05)
2	73.33 (20.47)	76.67 (11.82)
3	71.67 (21.89)	70.83 (11.79)
4	54.35 (12.73)	63.04 (11.39)
5	53 (16.66)	53.37 (14.60)

Note: SDs in parentheses

Table 7.24.
Means and SDs of LF nonword repetition by syllable length: Persisting pervasive speech subgroup

No. of syllables	LF nonword repetition T2	LF nonword repetition T3
1	46.15 (18.39)	55.77 (17.32)
2	55 (27.77)	62.5 (25.93)
3	54.17 (18.67)	55 (19.44)
4	44.02 (13.64)	48.37 (9.70)
5	36.54 (18.62)	46.63 (16.76)

Note: SDs in parentheses

7.2.13. Examination of subgroups through Cluster analysis

Cluster analysis was conducted to compare statistically generated clusters with the subgroup analysis. Cluster analysis is a technique that subgroups cases by maximising homogeneity of subjects within one cluster and maximising heterogeneity between the clusters (Hair, Anderson, Tatham & Black, 1998). Comparison of the clusters with the subgroup analysis can therefore examine: a) the proportion of children classified into "good"/ "poor" performance; b) the way in which classification occurs, i.e. are subgroups differentiated by different profiles of severity and/or pervasiveness? c) the stability of category membership; d) the relationship to clinical discharge rate reported in the therapy questionnaire data.

K-means cluster analysis was used to identify two clusters (two clusters were specified in order to make the results comparable to the subgroup analyses). The cluster analysis was carried out at each testing phase, T1, T2 and T3. Standardised variables were used as these eliminated effects due to scale differences (Hair et al., 1998). As the emphasis of the analysis was on the identification of subgroups within a speech disordered population rather than with comparison to the control group, z-scores using the speech disordered group's mean and SD were used. The following variables were entered into the analysis:

T1: AD: picture task, AD: same/different, AD: ABX, Word repetition, Nonword repetition, Articulatory naming, RAPT scores, Bus Story scores, Naming, TROG and BPVS, Nonverbal composite.

T2: AD: picture task, AD: same/different, AD: ABX, Word repetition, Nonword repetition, Articulatory naming, LF Word repetition, LF nonword repetition, RAPT scores, Bus Story scores, Naming, TROG and BPVS.

T3: AD: picture task, AD: ABX, Articulatory naming, LF Word repetition, LF nonword repetition, RAPT scores, Bus Story scores, Naming, TROG and BPVS, Nonverbal composite.

Cluster sizes are reported in Table 7.25.

Table 7.25.
Cluster sizes at each testing phase following K-means cluster analysis

	Cluster 1	Cluster 2
T1	46.5% (20/43)	53.5% (23/43)
T2	57.8% (26/45)	42.2% (19/45)
T3	78.3% (36/46)	21.7% (10/46)

Figures 7.4-7.6 illustrate the different performance of the two clusters at T1, T2 and T3. In these figures, z-scores calculated from the control data are used in order to show performance relative to normal development as well as relative to each other. In each case, children in Cluster 1 scored better than children in Cluster 2 on all measures (except for the nonverbal composite, measured at T1 and T3, where performance looks very similar), i.e. there is an overall difference across speech and language tasks. The clusters are particularly differentiated on speech output tasks, showing differences of severity, as well as pervasiveness.

It is also noted that the proportion of children falling within each cluster differs at each testing phase with a consistent trend for the higher performing cluster to increase over time. Only one child in the higher performing cluster moved down to the lower performing cluster over the course of the study.

Comparison of the T3 cluster in relation to the speech outcome classification also made at T3 reveals an important difference, as illustrated in Table 7.26. The T3 clusters produced through this analysis show a different proportion of children in the two clusters compared to the resolved/persisting subgroup analysis. In the cluster analysis, 78.3% of children are shown to be in what might be thought of as a resolving or 'good' speech group. The subgroup analysis found a much smaller proportion of children, only 27.7% of children, to have resolved speech (compared to controls). In total, 23 children classified with persisting speech difficulties at T3 were classified as being part of the better cluster. The clustering did not differentiate significantly according to which children were likely to have been discharged by T3. At T3, 62.1% of Cluster 1 had been discharged, and 30% of Cluster 2, a nonsignificant difference (Fisher's exact test, $p = .14$). In terms of discharge, this classification was therefore less successful at differentiating 'clinical concern' than the resolved/persisting criterion. The latter classification had found that children in the resolved speech subgroup were more likely to have been discharged than those in the persisting speech subgroup (see section 7.2.4), though there was not a perfect relationship between outcome classification and discharge.

Table 7.26.
Proportions of children by Speech outcome subgroups classified according to cluster

	Resolved speech subgroup (n= 13)	Persisting speech subgroup (n=34)
Cluster 1 ('better performing')	100% (13/13)	67.6% (23/34)
Cluster 2 ('worse performing'	0% (0/13)	32.4% (11/34)

Figure 7.4.
Cluster Profiles for the two-cluster solution at T1
(Z-scores of control data)

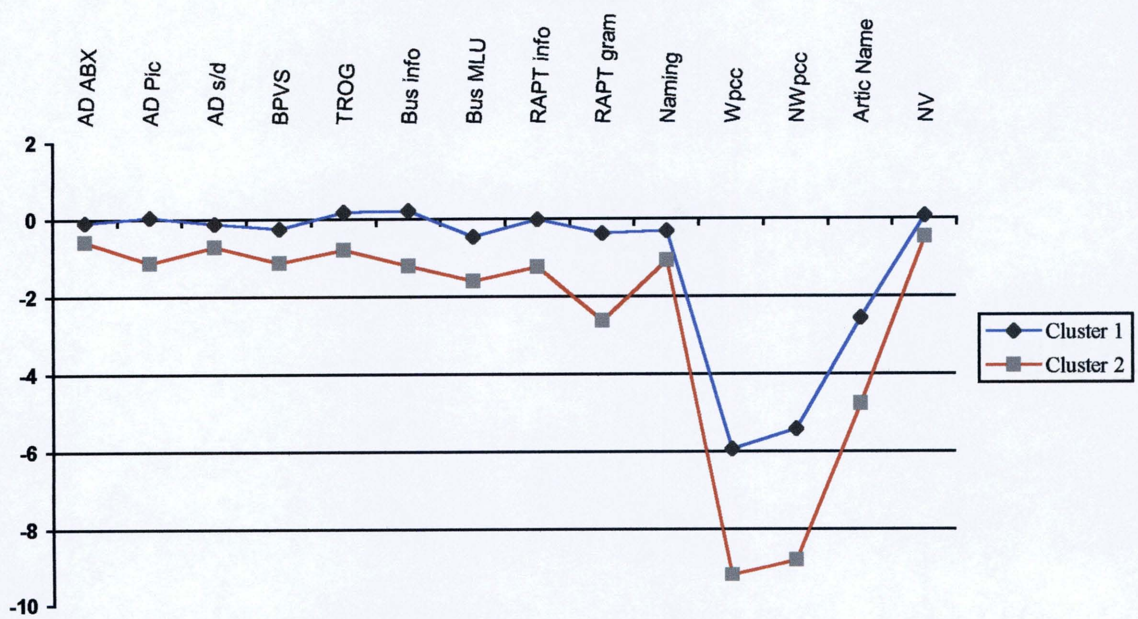


Figure 7.5.
Cluster Profiles for the two-cluster solution at T2
(Z-scores of control data)

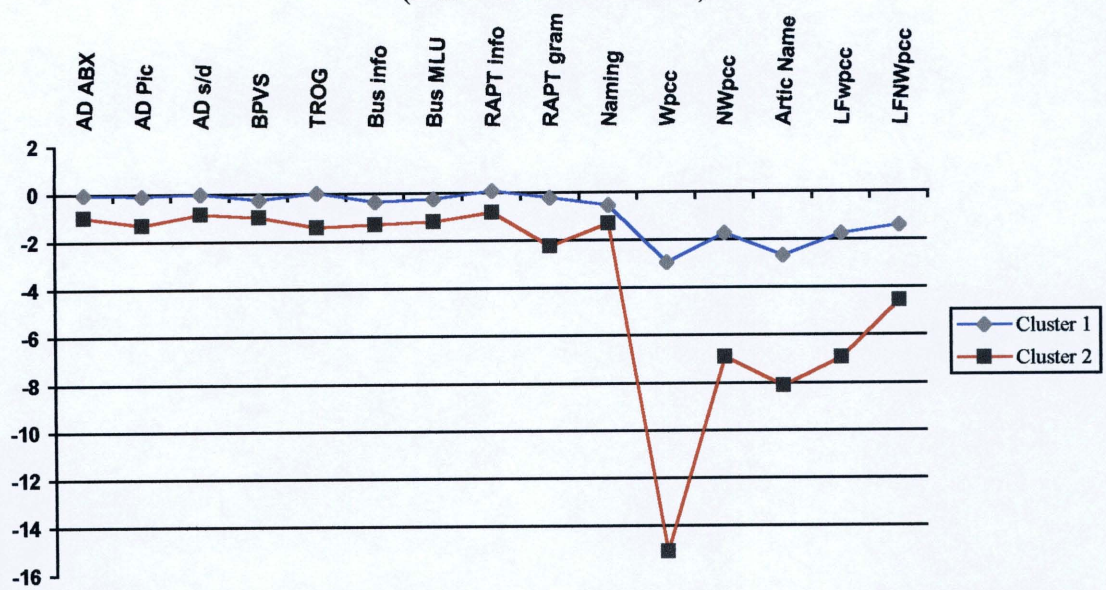
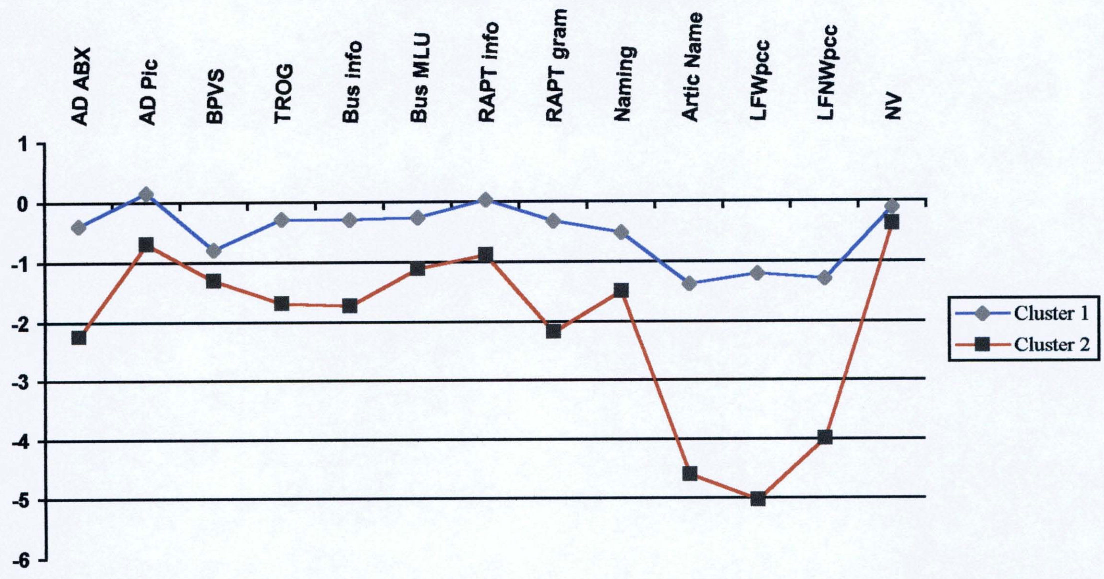


Figure 7.6.
Cluster Profiles for the two-cluster solution at T3
(Z-scores of control data)



7.3. Discussion

7.3.1. Defining resolved and persisting speech problems

Subgrouping by speech outcome has two main purposes. First, it aims to assess what proportion of children resolve their speech difficulties by age six-and-a-half and how many have persisting difficulties that may begin to affect their educational progress at this age; and second, to identify early on what measures might predict this outcome. According to performance on percentage of consonants correct on a composite measure of speech output compared to the control group, 28% of the speech disordered group had resolved speech at age six-and-a-half (i.e. above –1 SD). The majority of children continued to have persisting speech difficulties.

Although there are many ways of describing speech output and defining level of speech severity, it was decided to use this way of differentiating outcome: the usefulness of our criterion could subsequently be evaluated by exploring whether subgroups defined in this way performed differently on any of our measures. The way of defining 'resolved' and 'persisting' proved to be particularly stringent. It aimed to ensure that no child was classified as resolved if they had problems with more demanding speech tasks like nonword repetition, which had a range of one to five syllable nonwords. In reality, one child with noticeable nonword repetition difficulties at T3 was classified as resolved using the composite measure. However, if the classification had been based on one of the output tasks using lexical items, several children with nonword repetition difficulties would have been classified as 'resolved'. Nonword repetition can reveal deficits that might not be noticeable in word repetition or connected speech.

Indeed, data from the developmental and therapy questionnaires show that, although the children in the persisting speech subgroup may have scored less well on speech tasks, many of them were not considered to have functional speech difficulties any more. Nearly half of this group had been discharged from speech and language therapy, showing either a lack of concern about speech development from the clinician or the parent (it is possible that some children had been discharged through poor attendance, also an indication that parents may no longer have been sufficiently concerned about their child's speech development to take them to appointments). Additionally, over half of the parents (53.3%) felt their children did not have current problems with speech. Despite these perceptions, the persisting speech subgroup was scoring significantly less well on speech output measures (significance levels of $p<.001$ for the between-subjects factor) and the analysis principally looked for whether other measures in the test battery also differentiated the two subgroups.

7.3.2. Deficits of the persisting speech subgroup

7.3.2.1. Speech output, speech input and language measures

Differences were identified between the resolved and persisting speech outcome subgroups on speech processing and language tasks. The subgroups were differentiated on all speech output measures at all testing phases. Children whose speech resolves entered the study with better speech skills than those whose speech difficulties persist: they are differentiated in terms of the severity of their speech difficulty. Indeed, no significant differences were found between the resolved subgroup and the controls at T2 on speech output indicating that this subgroup's speech difficulties have resolved within a year of entry to the study. Severity and rate of speech development will be discussed further in sections 7.3.3 and 7.3.4.

The subgroups were also differentiated on speech input measures. Children with persisting speech difficulties scored less well on the AD: ABX task at all testing phases. Children with resolved speech skills had no deficits relative to controls on these measures. The subgroups were differentiated on a second measure of speech input at T2, AD: same/different. Although mean differences were noted on the AD: picture task, these differences were not significant. Nonetheless, significant differences between the persisting speech subgroup and controls were noted on this task at T1 and T2, indicating difficulties with a task that explicitly requires accessing of phonological representations. As a trend of difference was noted between the clinical subgroups on this measure, it is possible that overall subgroup differences were masked by some variable performance in both subgroups or that power was not sufficient to enable significant subgroup differences to be obtained.

On language measures, the two subgroups became more differentiated on a greater range of tests as they got older. At T1 and T2, the persisting speech subgroup scored less well on expressive language measures: the Bus Story (T1) and RAPT (T2). At T3, this subgroup was also scoring significantly less well on receptive language scores (BPVS and TROG). Mean differences were noted at T1 and T2 but no significant differences were found because there was wide variation across the whole group. Rather than indicating later emerging receptive language problems, this result can be interpreted as showing generally lower language performance – both receptive and expressive – in children with persisting speech problems. As noted below, no differences were found between rate of receptive language improvement on these measures.

It is also noteworthy that children with persisting speech difficulties performed less well than their original matched controls on Picture Completion at T3. No significant difference was found between the resolved and persisting speech subgroups on this measure, but this finding suggests that nonverbal skills may also need to be considered as part of the profile of deficit of children whose speech problems persist. Indeed, there is evidence from other longitudinal studies of children with SLI that one can expect a decrease in nonverbal performance over time (Stothard, Snowling, Bishop et al., 1998; Johnson, Beitchman, Young et al., 1999; Conti-Ramsden, Botting, Simkin et al., 2001). Such a decrease may be attributable to lack of development of inner speech, necessary to perform these types of task (Conti-Ramsden et al., 2001). It has also been hypothesised that speech/language difficulties stem from a problem of mapping sound and meaning, such that language difficulties, and also cognitive difficulties could develop out of an initial phonological deficit (Chiat, 2001). Alternatively, the result may reflect issues with obtaining pure measures of nonverbal skill.

Thus key clinical markers were identified that differentiate early on children's eventual speech outcome at age six-and-a-half. As some of these markers were identified through administration of standardised speech and language assessments in common use by UK speech and language therapists, the use of relatively routine or straightforward assessment of speech processing skill and language can be prognostic.

7.3.2.2. Developmental questionnaire data

Since few differences were noted between speech outcome subgroups on the developmental data, where differences were found, these are especially noteworthy.

Interestingly, children with persisting speech difficulties were reported to be later in saying their first words than normally developing children, by an average of nine months. They were not significantly different from the resolved speech subgroup. The resolved subgroup was not significantly different from controls, although there was a nonsignificant difference of 5.6 months between the resolved speech subgroup and controls. Later onset of speech in conjunction with similar rates of speech development (see section 7.3.3.) could go some way to explain why their speech skills lag behind other children in the group, and the controls. Alternatively, the finding may not indicate a maturational problem at all, but be the result of a more severe speech difficulty. A parent may not observe first words if these words are highly unintelligible, and may only report first words at a later point, when the words are recognisable.

The resolved speech subgroup had a higher incidence of asthma and had a higher incidence of reported coughs and colds (50% compared to 22.6% of the persisting speech subgroup), a difference which was not significant. Although this difference was not statistically significant, this result taken together with the difference on incidence of asthma could suggest that these children have been more susceptible to upper respiratory health problems at an early age than those with persisting difficulties. It could be hypothesised that their poor speech development is related to difficulties of a more peripheral nature. Additionally, significant correlations had been noted in the group as a whole with higher incidence of coughs and colds/asthma associated with less proficient speech output skills. Overall, these health problems are associated with poor speech development. In particular, they may be associated with those children whose speech problems are transitory. However, with small numbers in these subgroups, results obtained from questionnaire data can only give an indication of possible trends.

7.3.2.3. Therapy questionnaire data

Amount of therapy is obviously an important factor to consider when looking at progress in speech skills. However amount of therapy received did not significantly affect the outcome of the speech disordered groups; indeed, children with eventual poor speech outcomes were generally receiving more therapy than those with resolving difficulties, even at an early stage, though the variation in amount of therapy provided was enormous. There was some indication for an exception to the trend between T1 and T2, where there was no significant difference between subgroups on the percentage of children receiving regular therapy and on numbers of individual sessions received, whilst more were receiving group therapy. However, because of the overall variation of provision, such results would need to be treated with caution. Generally, it seems that the pattern of increased resources for children with persisting speech difficulties indicates that speech and language therapists were appropriately allocating increased resources to those children who were most in need of it, i.e. those with more persisting and pervasive speech and language difficulties. This increased contact time may have allowed this subgroup to make some progress that otherwise may not have occurred, but it did not appear to have a positive longer term impact of normalising their speech completely.

A different perspective emerged when examining those children (n = 25) with persisting speech problems who were receiving therapy in a community clinic setting, i.e. excluding children receiving therapy in a specialist setting. This revealed children receiving an average of only nine individual sessions, and 6 group sessions up till T1; an average of eight individual sessions and three group sessions between T1 and T2; and six individual sessions and two group sessions between T2 and T3. There was much variation in provision in this setting as well. Whilst they were generally receiving more therapy than those in the resolved subgroup were, the number of sessions in total seems small. Current awareness of provision issues have been highlighted by a randomised control trial (RCT) of pre-school children with speech and language delay who were attending community clinics (Glogowska, Roulstone, Enderby & Peters, 2000). One group received the normal intervention on offer, whilst the other group received a 'watchful waiting' approach, with little difference noted in outcome after 12 months. The RCT reported similar provision to the results reported here, despite the different client group. Provision was variable, but, in 12 months, children received an average of seven sessions. This is considered to be inadequate in terms of time and intensity (Law & Conti-Ramsden, 2000) and may explain the lack of progress made by the participants (there is also the issue of the type of intervention on offer).

The three children attending language units, and therefore receiving intensive therapy, showed different courses of progress. One child made rapid progress during the study, though still showed persisting speech difficulties. This was an unusual pattern, because she seems to be making more rapid progress than one would expect from the subgroup data, which found some accelerated improvement relative to the resolved subgroup, but not to this extent. This example may be an indication that intensive therapy from a young age will be beneficial. The other two children made less improvement over time, and still had very severe speech difficulties at T3. They differed from the other child, in having more pervasive profiles of difficulties, suggesting that response to therapy is likely to be related to level of speech difficulty and pervasiveness of profile.

It is thus possible that lack of intensity may be an issue in delivery of therapy, as proposed by Law and Conti-Ramsden (2000). Whether intensive therapy will work may also be related to the nature of the communication difficulty. The methodology used in this study makes it difficult to evaluate the effects of therapy and provision, and, indeed, this was never set out as an aim of the study. The findings of a negative relationship between amount of therapy and level of difficulty mirror other longitudinal studies where therapy was not specifically manipulated. In their study of children with speech and language difficulties, Bishop and Edmundson (1987a) found a rating of amount of therapy did not predict outcome. They conclude that because of the wide variation in the severity of the presenting disorder, it is difficult to uncover any positive effects of therapy. They do suggest, however, that without therapy, the children with greatest difficulties may have fared even worse.

7.3.2.4. Psychosocial questionnaire data

The subgroups were differentiated on one measure of psychosocial behaviour: hyperactivity. This finding needs careful interpretation. The measure of hyperactivity was taken from a psychosocial questionnaire completed by teachers at the last testing phase. Earlier attention skills were not rated and so it is not known whether this factor has a causal or co-occurring relationship with speech skills. The measure is likely to reflect poor attention skills and/or poor behaviour in the classroom, which could be a result of difficulties with classroom activities (findings on these children's literacy and other educational problems are reported in Stackhouse et al., unpublished).

7.3.3. Rate of speech and language development

One plausible hypothesis regarding speech outcome would be that children with resolving speech improve at a faster rate than children with persisting speech difficulties; or, that children with persisting speech difficulties are improving at a slower rate relative to the resolved subgroup and/or controls. In Chapter 4, it was found that children with speech difficulties appear to be improving at a faster rate than controls on speech output measures, though this was interpreted with some caution as controls were reaching ceiling on some speech output tasks. Nonetheless, it was concluded from this finding that the two groups were showing a differing pattern of development, with controls reaching their potential and children with speech difficulties continuing to improve.

An analysis of rate of change by subgroup found no evidence for arrested development on language or input tasks, with the persisting subgroup showing general improvement on tasks. The resolved subgroup did not improve significantly between T2 and T3 on AD: ABX and on the RAPT task, with skills plateauing. There were, however, significantly different patterns of development of speech skill. Between T1 and T2, the majority of both subgroups were performing at a 'faster' rate than controls, and certainly no children were improving at a slower rate than controls. However, proportionately more of the resolved subgroup was showing this greater change compared to the persisting speech subgroup. This pattern was reversed between T2 and T3. Many children in both groups still showed greater change than controls, but now the proportion of children with persisting speech difficulties was greater in this category compared to children with resolving speech on two speech measures: word repetition and articulatory naming. The pattern was different on nonword repetition where equal proportions of both subgroups showed greater improvement, compared to controls.

Thus between T1 and T2, the resolved speech subgroup consolidated their initial advantage over the persisting speech subgroup on absolute level of speech difficulty on the speech output tasks, as more children in this subgroup showed greater change. However, between T2 and T3, this improvement tailed off. This reflects the finding that by T2, the resolved speech subgroup was performing like controls, with no significant differences found on speech output tasks. Like controls, they would be reaching their potential and moving towards ceiling levels on these tasks. This is then reflected in the relatively greater proportion of children in the persisting subgroup, appearing to show greater improvement on word repetition. Their continuing development on this task looks like a faster rate of change. It is best interpreted as reflecting a delayed pattern of development, as their improvement must mirror earlier improvements made by the controls and resolving subgroup, at least in terms of gains in percentages of consonants correct.

Interestingly, the persisting subgroup's performance on nonword repetition does not follow this pattern. Equal proportions of children in each subgroup show greater improvement to controls on this task between T2 and T3, i.e. fewer of the persisting speech subgroup are making greater gains on this task than the other speech output tasks. This less accelerated pattern on nonword repetition is also illustrated by the finding that there is an increasing discrepancy between word and nonword repetition between T1 and T2, and to a greater extent, between T2 and T3 for this subgroup. For the resolved speech subgroup and controls, word/nonword discrepancy remains stable over time.

The finding indicates that children with persisting speech difficulties may be consolidating their skills and, through repeated exposure to words, accuracy improves. When repeating nonwords, however, they are less successful because they have had little or no exposure to these novel forms. The deficits evidenced by nonword repetition performance are relatively hidden deficits, which may therefore be masked in everyday communication, as lexical skills are improving. One might predict that, although these children's skills are showing overall improvement, they continue to be at risk for subtle ongoing speech processing difficulties. The type of deficit this result may reveal is discussed in Section 7.3.5.

7.3.4. Severity of speech difficulty

Rate of development did not successfully account for varying outcome. The initial and continued level of speech difficulty did. Children with persisting speech difficulty have more severe speech difficulties from an early age. Children with more severe speech difficulties are likely to have a poorer speech outcome. However, attempts to establish thresholds of severity found that whilst more severe speech difficulties were obviously related to poor outcome, with less severe problems it was more difficult to predict outcome. Using a median split of word repetition, for those children falling above the split, it was found that there was an equal likelihood of a poor speech outcome as a good speech outcome (a chance level).

Establishing a threshold of severity was also problematic. In order to identify a threshold, the level above which all children in the resolved subgroup performed was identified retrospectively for each speech output task at T1 and T2. It was then investigated whether children in the persisting speech subgroup all fell below this level of performance or whether there was overlap in severity. This analysis found that an 'absolute' level of performance did not differentiate the subgroups as some children with persisting speech difficulties fell within the lower range of performance of the resolved subgroup at T1 and T2. Whilst there was therefore not a clear-cut distinction in terms of severity between the resolved and persisting speech subgroups at each testing point, nonetheless, if a child scored below the range of the resolved subgroup at T1 and/or T2, then that child was at high risk for persisting speech difficulties. It was also the case that some children scoring above these thresholds were at risk for continuing speech difficulties.

7.3.5. Pervasiveness or severity hypothesis?

Children with persisting speech difficulties performed less well than those with resolved speech on a range of measures, suggesting that these children's difficulties are of a pervasive nature affecting several aspects of speech and language development. Analyses confirmed the general relationship between persisting speech difficulties and pervasive speech processing and language problems. However, not all children with persisting speech difficulties had more widespread difficulties, weakening the case for 'pervasiveness' as a completely reliable clinical marker.

One possibility is that the eight children with persisting but isolated speech difficulties did have other difficulties but the tests used were not sensitive to this, either at the start of or during the study. A second possibility is that the children may have had other processing/language difficulties prior to the start of the study. A third explanation arises from the analysis of speech data comparing these eight children with persisting but specific speech difficulties with a subgroup of children who had specific speech difficulties that resolved. Two results were noted: children with persisting specific speech difficulties had poorer performance on speech output tasks at T1 and T2 than the resolved specific speech subgroup (though not as severe as children with pervasive problems). Second, the subgroups differed in their rate of development on nonword repetition. Children with persisting specific speech difficulty did not make significant gains on nonword repetition between T2 and T3 comparable to significant gains made on word repetition or comparable to the resolved subgroup's significant gains on nonword repetition. This results in a greater word/nonword discrepancy than previously found. This finding was not affected by incidence of lexicalisations, as number of lexicalisations was negligible on the LF nonword repetition task, and there was no significant difference between the two groups (as reported in Chapter 4). Interestingly, this pattern was replicated in a subgroup of eight children who showed the most pervasive profile of deficits (i.e. speech output, speech input and language difficulties). These children also made significant gains on word repetition, but not on nonword repetition. One might assume that these children's input processing skills (both past and present) are having an impact on their ability to repeat unfamiliar phonological material. One could expect this impact to be greater for unfamiliar than familiar phonological stimuli, hence the difference between improvements on word and nonword repetition between T2 and T3. However, the subgroup of children with isolated but persisting speech difficulties showed no evidence of input processing difficulties, so this explanation is not the whole story. An interpretation in line with Stackhouse and Wells' (1997) model of speech processing (as illustrated in Figure 7.7) would be that this subgroup is having difficulty with the motor programming of complex unfamiliar phonological material. Input processing skills are intact, so difficulties appear to be located in output processing. These children's nonword repetition skills reflect an underlying motor programming difficulty that would hinder the future development of accurate speech skills and, in particular, the accurate establishment of new and complex phonological representations. This explanation could also apply to children with pervasive difficulties.

Figure 7.7.
Stackhouse and Wells' speech processing model (1997): **Word** and Nonword repetition routes contrasted, with the hypothesised deficit of motor programming highlighted

Image has been removed for copyright reasons

The children with specific and persisting difficulties do not have additional language difficulties that could be argued to account for their continuing difficulties. Since they also had more severe speech difficulties early on, there is evidence for the severity of the initial difficulty playing a role. The discriminant function analysis at T1 found that speech tasks alone classified 72.3% of children correctly by speech outcome. This was similar to the 75.8% of classification when speech input and language measures were also entered. However, the Bus Story alone predicted 80.9% of cases accurately, a finding in line with Bishop and Edmundson (1987a), who found that the Bus Story, measured at age 4, predicted language outcome at 5.6 in 83% of cases. Since the Bus Story involves speech skills as well, and it is recognised that intelligibility levels can affect scores, particularly on MLU, it is likely that this higher proportion of correct classifications is a result of the shared variance between speech output and expressive language skills. Additionally, the pattern reversed at T2 when speech tasks were more successful (83%) than language tasks (74.5%) (this time, the RAPT scores, which were the only tasks to differentiate the outcome subgroups at T2 and so the only language tasks entered into the discrimination analysis) at predicting speech outcome.

One could argue that the shared variance between speech and expressive language, favours a severity over pervasiveness hypothesis, i.e. problems look pervasive because children with more unintelligible speech will have lower scores on expressive language tests. However, this is not the whole story as receptive language skills and speech input skills are also compromised. These latter deficits would not seem to arise solely from problems with speech intelligibility, though one cannot rule out a complex interaction of skills occurring. The severity of the speech disorder is related to how pervasive the speech and language difficulty is, as children with more pervasive speech difficulties are the ones that also had more severe speech difficulties early on. Cluster analyses also reflect the role of both level of speech severity and pervasiveness of difficulty as the clusters are differentiated on both these dimensions. Whether a severity or pervasiveness hypothesis most closely accounts for speech development and outcome is discussed in more depth in the final chapter.

7.3.6. Motor programming deficit

The last section raised the possibility that children with persisting speech difficulties may have motor programming difficulties because some failed to make progress on the nonword repetition task between T2 and T3. Such a hypothesised motor programming deficit only became apparent between T2 and T3, in the changing word/nonword profile (for the whole of the persisting speech subgroup, reported in 7.3.3.) and the important finding of no significant improvement on nonword repetition for the two smaller persisting speech subgroups (persisting specific and persisting pervasive). There was a small significant increase in discrepancy between T1 and T2 for the children with persisting speech (in the larger subgroup analysis) but this was not apparent in the analyses employing smaller subgroups.

It is important to explore the reasons for this finding, and to clarify whether a motor programming deficit is an underlying factor in these children's speech development, or a later emerging phenomenon. There could be several reasons for the lack of signs of emerging discrepancy between T1 and T2 for the smaller subgroups: methodological factors, including task design, and theoretical explanations, relating to change in speech processing and language systems. Some of these analyses were based on small subgroups and lack of differentiation may relate to the lack of power in using small subgroups. A more prominent methodological factor relates to the use of two repetition tasks, the original version administered at T1 and T2, and the extension, administered at T2 and T3, that included LF words (or their matched nonwords) and a wider range of syllable length. It is possible that differences in results could therefore be attributed to these differences in word length and word frequency between the tasks. Effects of stimulus length and wordlikeness have been noted in the literature (Gathercole et al., 1991). Indeed, at T2, when both the original and extension tasks were administered, children generally performed less well on the extension tasks that included these lower frequency stimuli, had longer word/nonwords and greater phonological complexity. Whilst an overall poorer performance could be attributed to these factors, it is not clear whether any of the factors may contribute to the observed pattern of discrepancy between T2 and T3. In fact, examination of changes in performance between T2 and T3 by word length did not find a clear-cut relationship between accuracy and word length. The persisting specific speech subgroup did make improvements on 1-syllable nonword repetition, and not other syllable lengths, but it was apparent from the persisting pervasive subgroup who made no improvements across syllable length, that lack of improvement was not attributable to word length effects. There is therefore no strong evidence that there is less improvement between T2 and T3 for longer nonwords compared to shorter ones and so no reason to suggest that the inclusion of longer nonwords in the original repetition tasks might have facilitated the identification of an earlier emerging discrepancy.

The effect of word frequency also needs consideration. Wordlikeness effects have been reported on nonword repetition tasks (Gathercole, Willis, Emslie &, Baddeley, 1991; Dollaghan, Biber & Campbell, 1995; Gathercole, 1995) with higher accuracy obtained when nonwords are perceived to be more wordlike. There is the possibility that the nonwords in the original version which were derived from high frequency words were too wordlike (e.g. /bɹɪʃ/ or /ˈtɹɛktɪ/), resulting in the narrow discrepancy between word and nonword repetition as well as high levels of accuracy on both tasks. The improvement on nonword repetition between T1 and T2, even by children with persisting difficulties, could be partly attributable to a wordlikeness effect. Less wordlike stimuli may have revealed less change over time, and so have been earlier evidence of a motor programming deficit.

Also, the emerging discrepancy between T2 and T3 may be a result of wordlikeness effects. At T2, it is likely that many of the words in the LF word repetition task were unfamiliar to the children and could have been treated as nonwords (e.g. CHRYSANTHEMUM or ANCHOVY), i.e. the words were too nonwordlike for young children (but not all stimuli, as a word/nonword discrepancy was still found). This would also be the case for children with receptive vocabulary difficulties who will treat words not in their vocabulary as nonwords (though the word/nonword discrepancy was noted in children with no additional language difficulties). By T3, some of these words would now have become more familiar, and also be produced with more accuracy, whilst the nonwords remain unfamiliar, and lack of improvement is noted. In sum, motor programming difficulties may exist earlier, rather than be emerging later. These difficulties may be masked by the wordlikeness of some of the nonwords on the original version (thus with no possibility of observing an increasing discrepancy), and/or by the nonwordlikeness of the words on the extension task (thus processing the words as well as the nonwords as largely unfamiliar at T2, resulting in a smaller discrepancy). In this latter case, it is the improvement on the word repetition task that reveals a persisting nonword deficit.

Discussion of these methodological issues is central to the interpretation, and word length and wordlikeness effects need to be explored further in future research to examine their effect more precisely in relation to speech output deficits. Phonological complexity is another factor requiring closer inspection, and has been examined in studies of nonword repetition (Gathercole et al., 1991; Bishop, North & Donlan, 1996).

The patterns of word/nonword performance are nonetheless likely not to be solely attributable to task design, but to reveal important insights into the changing speech processing system. Whilst lack of change on nonword repetition, i.e. motor programming deficits, was only noted between T2 and T3, it is argued that poor *word* repetition throughout is also a manifestation of motor programming deficits. Inaccuracy in word repetition (if processing occurs via a lexical route, which is highly probable) could reflect an inaccurate motor program. A motor program, logically, develops through motor programming skills. As words become more practised and more familiar over time (as vocabulary expands), their motor programs will become more accurate. However, the motor programming deficit, it is argued, which was responsible for these inaccurate motor programs, will still persist and manifest itself in the repetition of unfamiliar and unpractised nonword stimuli. Difficulty with word repetition is therefore indirect evidence of a motor programming deficit. The evidence from nonword repetition and the comparison across word and nonword repetition over time offers further clarifying evidence for a problem with encoding phonological information ready for articulation, i.e. a problem of motor programming. The different pattern of word repetition and nonword repetition also suggests that lower level articulatory problems are unlikely to be a sufficient explanation for speech difficulties, as you might expect such difficulties to exert a similar role on word as nonword repetition. The role of input skills in output skills is followed up in Chapters 8 and 11.

7.3.7. Subgroup analysis

The theme of subgrouping was extended in this chapter. A successful subgrouping would find distinct and homogeneous groups within a heterogeneous sample. The subgroup analysis looking at the co-occurrence of language difficulties (in Chapter 6) did find distinct differences in performance according to presence or absence of additional language difficulties. However, it was unclear from the analysis whether the subgroups represented qualitatively different entities or were, in fact, on a continuum of severity. According to such an argument, the more severe the speech difficulty, the more likely it would be that a child would show a depressed language score due to reduced intelligibility. Nonetheless, results on the speech input measures do suggest that there are qualitative differences in speech processing skill according to subgroup, although these differences were not consistent over the three testing phases.

It is also worth noting that children with the pervasive pattern of speech/language difficulty that was identified could in another guise be described as specific language impaired (SLI). In a study of SLI, Stark and Tallal (1981) excluded children from their criteria if their articulation age was more than six months below their expressive language age, which would be the case for most of the children in this study. However, other diagnostic criteria like the World Health Organization classification (International Classification of Diseases, ICD-10, 1993) do not mention speech level, although, according to this classification, some children in this study might be excluded because their language difficulties were not severe enough (they were required to fall below 2 SDs of the mean). Whilst criteria for defining SLI vary considerably (see Bishop, 1997, for a full discussion), these children could be said to fall at some point along an SLI continuum. The main difference lies in their selection to the study, where children with speech difficulties were sought, and their primary difficulty was considered to be this presenting speech problem. These children therefore might not be drawn from a different population, but just from a different point on the spectrum of the same population. Whether children with specific speech difficulties, and no other language difficulties, are also part of this spectrum is another issue that cannot be addressed using this dataset. Certainly, it is possible to present with a differentiated profile of speech and language skills, and the second subgroup analysis shows how these different profiles are differentially related to speech outcome.

The second subgroup analysis that classified children by speech outcome found a similar set of results to the first, namely that children with additional language difficulties and speech input problems tend to have a poorer prognosis in terms of speech skills. As the subgroups were identified retrospectively, differences associated with the level of speech are more clear-cut than in the prospective analysis. The subgroup of children classified with resolved speech by the end of the study actually appeared to have resolved speech at the age of five (no significant difference to the control group on speech output tasks). This subgroup tended to have specific speech difficulties, without associated language or speech input problems. One could characterise their difficulties as developmental delay that resolves relatively quickly. The resolved subgroup represents what Shriberg et al. (1994) call 'short-term normalization'. This label defines a child whose speech resolves within approximately two years of the identification of the speech problem. Even for children not receiving intervention, there is likely to be some level of improvement, whether short-term or long-term. Law et al. (1998), in their review of three studies of the natural history of speech disorder, report a median persistence of 50%, with a large range from 22-100%. Shriberg et al. (1994), in a study where children were receiving intervention, reported 18.5% of their group resolved at follow-up, slightly smaller than the 28% reported in this study. This subgroup analysis therefore confirms Shriberg et al.'s finding that the majority of children's speech difficulties persist. However, it does not reflect parental or clinical opinion, which showed over half of respondents were no longer concerned with the child's speech.

7.3.8. Cluster analyses

The cluster analyses which tested for homogeneous subgroups were conducted to investigate whether the patterns of performance revealed by these subgroup analyses, e.g. severity, pervasiveness, would be replicated in a statistically generated subgrouping. As noted, the two subgroups that were generated at each testing phase were distinguished by both severity of the speech difficulty and by lower scores on input and language tasks, thus reflecting both the speech/language subgrouping of Chapter 6, and the outcome subgrouping of this chapter. The outcome classification did not share a very close relationship with the discharge from therapy data as many children discharged from therapy still had speech difficulties on some of the test measures, suggesting that this classification might not reflect a notion of clinically/functionally resolved speech. This outcome classification might therefore appear too stringent, at least in functional terms. However, the better performing cluster subgroup at T3 was not more successful at identifying a 'good outcome' subgroup, clinical or otherwise. The better performing cluster at T3 was much larger than the good outcome subgroup (78.3% vs. 27.7%) and included 37.9% of children who had not been discharged. The cluster analysis therefore did not reflect notions of clinical concern, as evidenced by the lack of relationship between the grouping and the discharge measures, nor did it reflect the proportions of impairment of the more stringent speech outcome classification.

Whilst the cluster analysis was a useful exercise in comparing statistically generated classifications to clinically or theoretically motivated classifications, the results show that there is a mismatch between these different modes of classification. It is argued that the more stringent definition of outcome employed by the outcome analysis has been the most successful subgrouping at revealing subtle but important speech processing deficits in the persisting speech subgroup. It also had some degree of success at accounting for the varying performance of the population. There was a different pattern between the resolved and persisting subgroups that was mediated by both severity of the speech disorder and pervasiveness of the speech processing and language skills. To some extent, an outcome classification therefore accounts for the variation in performance across language tasks and the different levels of performance on speech output tasks. That these differences were found validates such a stringent definition of outcome. Children who no longer have functional speech difficulties still have speech processing difficulties that may persist, with implications for literacy development. However, the persisting subgroup was not homogeneous in performance. Some of these children showed specific and persisting speech difficulties, in the absence of other difficulties, illustrating that heterogeneity was still evident in the persisting speech subgroup.

7.3.9. Summary

Whilst the subgroup analysis supplies useful information in distinguishing resolved from persisting speech difficulty, the lack of homogeneity within the persisting subgroup qualifies the extent to which these clinical markers are wholly reliable. They are a large subgroup, and the majority of the original sample, so remaining fairly undifferentiated. Further subclassifications could be warranted, e.g. by differentiating children along three rather than two dimensions (speech output, language *and* speech input) or by classifying by several levels of speech severity. The results certainly show that it is important to consider severity of speech difficulties and pervasiveness of speech processing problems when measuring speech development in a clinical setting. For children who have pervasive speech and language difficulties at T1, it is very likely that these difficulties will persist. But for those with more specific speech difficulties it is less easy to predict whether their difficulties will resolve or persist, as there are children in both outcome subgroups with these specific speech problems. The observation that severity might mediate the outcome of children with specific speech problems does give some indication, but this result was based on very small numbers. The increasing word/nonword discrepancy apparent across the persisting subgroup also hints at a common mechanism that mediates atypical development. Further follow-up of the cohort is needed to examine whether such a profile will continue to reflect persisting speech difficulties.

In summary, rather than establishing homogeneous subgroups, profiles of performance across tests have been uncovered. These profiles are differentiated from each other by speech severity, which can be described as a persisting or a resolving speech problem; and by specific or pervasive problems, which can be described as a presence or absence of language or speech input difficulties. The stringent manner in which speech outcome was defined may be at odds with the clinical and/or parental view of speech outcome, and this may not reflect these children's functional communication skills. However, it may more accurately reflect actual speech and language performance, particularly speech processing skills that, while they may support everyday communication, are not adequate for more challenging speech processing tasks (e.g.

nonword repetition) where performance is still not in line with normally developing peers.

Results reveal both associations and dissociations between speech and language measures. The next chapter looks in more detail at associations and dissociations on the speech processing measures specifically, and how these may be interpreted according to processing demands, which may, in turn, relate to how these skills will develop and improve further. In the chapter following this further analysis, relationships between skills will be examined in more detail. Subgroup analysis has revealed general associations between skills, by showing that pervasiveness of difficulties exists. The analysis does not show precisely how these skills might interact with each other, however, nor whether some exert a causal influence on the development of others. Thus, in Chapter 9, relationships, both concurrent and longitudinal, are examined to elucidate both normal and atypical speech development.

Chapter 8
Psycholinguistic analysis of speech output and speech input tasks

8.1. Introduction

In Chapter 6, it was established that some of the speech disordered group have deficits at the levels of speech input and phonological representations in addition to their presenting speech output difficulties at T1 and that these difficulties can persist over time. Moreover, such deficits are more likely to occur in children with persisting, severe and pervasive speech and language difficulties. The analyses did not examine patterns of processing deficits, i.e. whether there are particular relationships between tasks for the speech disordered group or for individuals within the group. However, examination of different patterns of performance between word and nonword repetition and changes over time of these patterns, in Chapter 7, revealed an interesting pattern of performance, with children who have persisting speech difficulties developing a greater discrepancy between word and nonword repetition over time. Some of these children did not make significant gains on nonword repetition between T2 and T3. There was thus some motivation to explore word/nonword patterns further.

Examining individual processing patterns is also driven by acknowledged shortcomings associated with group analyses. Group data, especially in the adult cognitive neuropsychology literature (Shallice, 1988), is commonly criticised for obscuring individual difference and masking processing deficits. As most clinical groups are heterogeneous in character, averaging performance across participants is likely to obscure the most relevant aspects of performance (Temple, 1997). Indeed, this criticism can be made of the group studies of Dodd et al. (1989) and Williams and Chiat (1993) which compared group and subgroup performance across tasks as well as the analyses of group and subgroup reported in Chapters 4 and 7. Case studies are viewed by cognitive neuropsychologists as the preferred procedure for examining cognitive architectures. Identification of dissociations and double dissociations on tasks are regarded as the principal form of evidence for the existence of differentiated subsystems. In addition, this theoretical approach has successfully transferred to clinical practice. A case study methodology is readily transferable to a clinical setting, where clients are assessed on an individual basis, and characterised as having a unique profile of strengths and weaknesses, rather than as having a generic impairment with an associated label.

However, rather than adopt a case-study approach with this data, it was decided to examine the pattern of distribution of certain speech processing skills across the whole system. If one is to examine underlying speech processing skills and to seek to explain speech difficulties according to patterns of processing, it is of clinical relevance to examine the frequency with which such patterns occur in the population. Thus this analysis avoided selecting children who were marked by unusual processing patterns or examining those who seemed 'typically' disordered, but instead would look at the entire range. The group methodology can therefore allow for an examination of the patterns of dissociation or differing performance across the group which is of direct clinical importance.

Dodd (1995) has criticised a case study approach because often atypical children are studied which, she argues, whilst of theoretical import, makes the application of findings to clinical practice limited. Dodd cites Bryan and Howard's (1992) case of DF's superior nonword repetition, as an example of this atypical performance. Since this criticism, the case of Murray has been reported (Hewlett et al., 1998), also in order to develop a theoretical model, but it is not clear how frequent such a pattern of performance might be. Whilst it seems from the group studies of Dodd et al. and Williams and Chiat, and from other case studies (e.g. Stackhouse and Wells, 1993) that superior nonword repetition is not found amongst all children with speech difficulties, identifying contrasting patterns of performance could move us towards a way of subclassifying children according to processing deficits. As well as examining word/nonword repetition skills, this chapter will explore specific processing patterns between two speech input levels: phonological recognition and phonological representation, as modelled by Stackhouse and Wells (1997), patterns that have been less explored in the literature.

8.1.1. Dissociations on speech input tasks

Thus, one aim of this chapter is to examine whether there are patterns or profiles of performance, how frequent these patterns might be and whether certain patterns are associated with a poorer speech outcome. First, patterns of performance amongst the three speech input tasks (where the child was not required to give any verbal output in order to complete the task) will be examined. Two levels of speech processing were assessed through the use of three Auditory discrimination tasks. The AD: same/different task and the AD: ABX task both tap the level of 'phonological recognition'. The first task included word and nonword pairs. In the case of the word pairs, phonological representations could be accessed; in the case of nonword pairs, no phonological representations could be accessed. In the ABX task, as nonword stimuli alone are used, 'phonological recognition' is assessed, without the accessing of phonological representations. The AD: picture task does require the accessing of stored lexical representations as well as lower level discrimination skills at 'phonological recognition'. These processing routes are illustrated in Figure 8.1. Whilst group differences were uncovered on these three tasks and a subgroup of the sample were found to have difficulties on these measures, it is not clear what the profile of performance is across the speech disordered group on these two levels of processing. Four profiles of performance can be predicted:

1. A specific deficit at the level of phonological recognition
2. A specific deficit at the level of phonological representation
3. Deficits at both levels of phonological recognition and phonological representation
4. Deficit on neither level.

Establishing whether there are dissociations between these two levels using these three measures is of theoretical and clinical relevance. Theoretically, the finding of dissociations in this dataset would verify the usefulness of conceptualising two levels of processing as proposed by Stackhouse and Wells. Whether dissociated or associated deficits are likely, and how common particular patterns of performance are in this population, is important if this model is to have clinical applications. In evaluating this type of approach, it will be necessary to revisit the methodological issue of reliability. Task comparison requires use of tasks that can be appropriately compared.

8.1.2. Dissociations on speech output tasks

As well as examining performance on speech input tasks, speech output tasks can address the question of whether stored representations are implicated in a speech processing difficulty. Nonword repetition has been cited as involving a range of skills: ability to create new motor programs (Stackhouse & Wells, 1997), an indicator of lexical development (Gathercole, Willis, Baddeley & Emslie, 1994), a measure of short term memory (Gathercole & Baddeley, 1990) and related to input processing (Dollaghan, Biber & Campbell, 1995). By specifically comparing nonword repetition with other speech output tasks, it is possible to extrapolate processing demands. More common than comparing input tasks (where no verbal output is required), several researchers have examined differences of performance on word repetition compared to nonword repetition in children with speech difficulties (Dodd et al., 1989; Bryan & Howard, 1992; Williams & Chiat, 1993; Stackhouse & Wells, 1997; Hewlett et al., 1998). Different patterns of performance are postulated to indicate different processing deficits (see Figure 8.2). In principle, three patterns of performance are possible:

1. Word and nonword repetition follow a similar pattern to controls
2. Word repetition is significantly better than nonword repetition
3. Nonword repetition is significantly better than word repetition.

Identifying these patterns is dependent on collecting normative data. Work by Vance et al. (1995) emphasised the importance of understanding the normal development of speech processing skills. They found that word repetition is generally more accurate than nonword repetition in young children and this finding was replicated in Chapter 4. Indeed ANOVAS reported in Chapter 4 found no group differences between the speech disordered group and the controls in the pattern of performance between the word and nonword repetition tasks. A similar profile was shown for both groups, that word repetition was significantly more accurate than nonword repetition at all testing phases. However, results from Chapter 7 revealed an increasing word/nonword discrepancy between T2 and T3 for children with persisting speech difficulties, suggesting differing processing skills are associated with the later development/outcome of speech difficulties.

It is possible that, whilst indicating an important pattern in disordered speech development, both the group and subgroup analyses mask more subtle patterns of processing. For example, some children could be more accurate on word repetition than nonword repetition and others could show a reverse pattern (i.e. pattern 3). It is also possible that children with speech disorders might show a larger discrepancy than controls between the two tasks (i.e. pattern 2). Pattern 2, where the discrepancy between word and nonword repetition is greater than what one might expect in normally developing children, may show that the child has difficulties in creating a motor program for a new word (Stackhouse & Wells, 1997). Pattern 3, where nonword repetition is better than word repetition, is attributable to a failure to update stored motor programs. However, Hewlett et al. (1998) attribute this pattern to inaccurate phonological representations. Whichever of these interpretations is assumed, this pattern of deficit is said to compare the accuracy of some kind of stored lexical knowledge (whether the phonological representation or the motor program) compared to an articulatory or motor programming level. Such a pattern shows that a child is failing to update stored information, but that bypassing stored information results in greater speech production accuracy. Two cases of this pattern of performance have been reported in the literature, but it is not known how common this profile might be.

8.1.3. Patterns of dissociation over time and the relationship of these patterns to outcome

A psycholinguistic framework which postulates different processing routes and different levels of deficit allows researchers and clinicians to characterise speech disorder as a speech processing disorder. Some studies, either through case series or group studies, have attempted to locate where the locus of deficit might lie in the speech processing system, and so identify a causal factor (Chiat, 2000). However, Stackhouse and Wells have argued that different children may show different processing deficits and that, within one child, different aspects of the child's speech difficulty might be located at different levels of the speech processing system. Further, the speech difficulty is said to be of an 'unfolding nature'. Over time, the speech difficulty is manifested in different ways, and may become a difficulty with phonological awareness or literacy. The case of Zoe illustrates an unfolding deficit (Stackhouse & Wells, 1993; 1997). Whilst a speech processing model like the one proposed by Stackhouse and Wells conceptualises the processing routes involved in different tasks and thus postulates processors, it is not a developmental model and so cannot account for the unfolding nature of speech difficulties. A one-off psycholinguistic assessment offers only a 'snapshot' of a child (Stackhouse & Wells, 1997) at a particular age, whereas reassessment over time is an opportunity to gain more of a developmental perspective. The model, however, does not predict whether or how a problem might change. Since the problem is developmental, an account of it must not only characterise the problem at one particular time, but also account for changes over time. Examining group change in these patterns of performance is therefore important in order to assess whether patterns generally are stable developmentally, or subject to fluctuation.

The relationship between patterns of deficit in these areas and speech outcome is also a central question in terms of understanding the development of speech difficulties. If speech processing profiles are different to those expected in normal development as indicated in Chapter 7, it could be hypothesised that the continuing development of speech skills will be disordered and problems slower to resolve. Thus prognosis of outcome may be achieved, not just through the administration of certain assessments, but by comparison of certain tasks. It is therefore important to investigate whether there is a relationship between unusual patterns of processing and speech outcome and whether any patterns are stable or transitory over time.

8.1.4. Examining predicted associations between tasks

A psycholinguistic approach makes predictions about the specific relationships between certain skills. For example, the ability to repeat words and the way this ability has developed might be more closely related to the 'phonological representation' level than to the 'phonological recognition' level. In order to repeat a word, one is likely to access the phonological representation of the stimulus. In contrast, repeating nonwords is likely to call on 'phonological recognition' skills. Nonwords have no stored phonological representations, so lower level input skills will be mainly required in order to process a nonword stimulus.

Using a multiple regression analysis, one might hypothesise that certain skills will predict unique variance, over and above related skills in another skill, measured concurrently or longitudinally. Therefore, by examining whether one task predicts unique variance in the development of another task, over and above another task, one is assessing whether the two potential predictors are separable and dissociable in their relationship with another task, i.e. whether phonological representations or phonological recognition share different relationships or degrees of relationship with an output task.

As well as exploring dissociations between tasks in order to validate a psycholinguistic approach, it is therefore important to examine dissociations in relationships between tasks that might be predicted from the speech processing model through multivariate statistical analyses. From Stackhouse and Wells' model, the following predictions could be made:

1. The AD: picture task will predict unique variance in word repetition (because the AD: picture task requires the accessing of phonological representations which are likely to be accessed in a word repetition task).
2. The AD: picture task will predict unique variance in articulatory naming (because the AD: picture task requires the accessing of phonological representations which must be accessed in a Naming task).
3. The AD: ABX task will predict unique variance in nonword repetition (the ABX task using nonwords taps lower level auditory processing which will be an important skill in processing nonwords where there are no established phonological representations).

Multiple regression analysis will be reported that explores these predicted associations. These relationships will be explored both concurrently and longitudinally as one would predict that a difficulty at one level of processing might selectively affect speech output skills and the development of speech output skills related to this level.

8.1.5. Research questions

1. Do children with speech difficulties show different patterns of performance between the levels of phonological recognition skills and phonological representations? If so, are these patterns stable over time?
2. Do children with speech difficulties show different patterns of performance between word and nonword repetition? If so, are these patterns stable over time?
3. Are any of these patterns of performance related to speech outcome?
4. What is the relative contribution of the levels of phonological recognition and phonological representation to concurrent measures of speech output?
5. What is the relative contribution of the levels of phonological recognition and phonological representation to later measures of speech output?

Figure 8.1.
Stackhouse and Wells' speech processing model (1997): Routes for the AD: picture task and the AD: ABX task

Image has been removed for copyright reasons

Figure 8.2.
Stackhouse and Wells' speech processing model (1997): Word and nonword repetition routes

Image has been removed for copyright reasons

8.2. Results

8.2.1. Patterns of performance on phonological recognition and phonological representations

In order to examine whether there was a different performance between speech input processing levels, the percentage of children showing dissociation according to Stackhouse & Wells' model was calculated. The percentage of children showing difficulty at the level of 'phonological recognition' was calculated, i.e. the proportion scoring less well than controls on the AD: same/different task and the AD: ABX task at T1 and T2, and the AD: ABX task (the only task administered at T3 that tapped this level). The percentage showing difficulties at the level of phonological representations, i.e. the AD: picture task was also calculated. Associations in performance were also examined by calculating the percentage of children showing a combination of difficulties.

These percentages are reported in Table 8.1 for each testing phase. Dissociation was noted at each testing phase, as well as patterns of association. The pattern of dissociation and association changed over time. At T1, 21% of the group had a deficit at the level of phonological representations. Only 11% had a deficit at the level of phonological recognition, and a similar proportion for the combined score. At T2, the main change was a decrease in the number of children with phonological recognition deficits and an increase in those with a combined deficit. At T3, the pattern of performance again changed, with a decrease in the number of children with phonological representation problems and combined problems, but a large increase in the percentage of children with phonological recognition problems, to 30% of the group.

Thirty-five percent of children showed no difficulty on either level throughout the study. For the rest of the group, there was a lack of stability over time in classification. Only one child showed one type of persisting deficit, and indeed only one child showed a persisting deficit on both levels of processing from T1 to T3. Instead children's performance was highly variable over time with shifting patterns of input processing difficulty observed.

Table 8.2 reports the distribution according to speech outcome classification. This shows that only one child in the resolved subgroup (and only at T3) exhibited difficulties on tasks of phonological recognition, and no children in this subgroup showed a 'double deficit' on both phonological recognition and phonological representations. A proportion (2/3 children) in this subgroup did have difficulties on phonological representations at different time points, but there was much less incidence of this than in the persisting speech subgroup. Overall, 61.5% of the resolved subgroup showed no input deficit compared to 23.3% of the persisting speech subgroup.

8.2.2. Performance on word and nonword repetition

No difference was found between the speech disordered and the control groups in the relationship between word and nonword repetition (as reported in Chapter 4). However, an important, emerging discrepancy between T2 and T3 was noted for children with persisting speech difficulties (Chapter 7). Thus the first analysis masked individual difference and it is possible that the second analysis using outcome subgroups may also have masked other patterns of word/nonword discrepancy. This analysis will therefore examine whether all children with speech difficulties performed like the controls on word versus nonword repetition, i.e. whether they were always better on word repetition than nonword repetition. It will also be seen whether patterns of performance were of a similar proportion to the controls and whether there is any relationship between pattern and speech outcome.

First, new scores were created by subtracting nonword repetition from word repetition (at T1 and at T2) and by subtracting LF nonword repetition from LF word repetition (at T2 and at T3). This new score shows that, on the whole, word repetition is better than nonword repetition and that the Extension tasks reveal greater discrepancies than the Original repetition task. An interaction had been found on Word type x Time for the Original repetition task and this is reflected by a bigger discrepancy between word types at T2 than T1 (see Table 8.3). However, no significant interaction was found on the Extension repetition task, despite an increase in the discrepancy score for the speech disordered group at T3.

Table 8.1.

Percentage of children showing deficits at the level of phonological recognition versus phonological representations

	Deficit at level of phonological recognition only (composite of AD: ABX and same/different at T1 and T2; ABX at T3)	Deficit at level of phonological representations only (AD: picture task)	Deficit at level of phonological recognition and representations	No deficit
	% of the Speech disordered group	% of the Speech disordered group	% of the Speech disordered group	% of the Speech disordered group
T1	11.4 (5/44)	22.7 (10/44)	11.4 (5/44)	54.5 (24/44)
T2	4.3 (2/47)	17.2 (8/47)	21.3 (10/47)	57.5 (27/47)
T3	30.4 (14/46)	8.7 (4/46)	8.7 (4/46)	52.2 (24/46)
T1 and T2	2.3 (1/44)	2.3 (1/44)	9.1 (4/44)	43.2 (19/44)
T2 and T3	4.3 (2/46)	2.2 (1/46)	2.2 (1/46)	41.3 (19/46)
T1, T2 and T3	2.2 (1/43)	0 (0/43)	2.3 (1/43)	34.9 (15/43)

Table 8.2.

Percentage of children by speech outcome subgroup showing deficits at the level of phonological recognition versus phonological representations

	% deficit of phonological recognition		% deficit of phonological representations		% deficit of phonological recognition + phonological representations		% No deficit of phonological recognition or phonological representations	
	Resolved[1]	Persisting	Resolved[1]	Persisting	Resolved[1]	Persisting	Resolved[1]	Persisting
T1	0 (0)	16.1 (5)	23.1 (3)	22.6 (7)	0 (0)	16.1 (5)	77 (10)	45.2 (14)
T2	0 (0)	5.9 (2)	15.4 (2)	17.6 (6)	0 (0)	29.4 (10)	84.6 (11)	47.1 (16)
T3	7.7 (1)	39.4 (13)	15.4 (2)	6.1 (2)	0 (0)	12.1 (4)	77 (10)	42.4 (14)
T1-T2	0 (0)	3.2 (1)	0 (0)	3.2 (1)	0 (0)	12.9 (4)	61.5 (8)	35.3 (11)
T2-T3	0 (0)	6.1 (2)	0 (0)	0 (0)	0 (0)	3.0 (1)	69.2 (9)	30.3 (10)
T1-T2-T3	0 (0)	3.3 (1)	0 (0)	0 (0)	0 (0)	3.3 (1)	61.5 (8)	23.3 (7)

(n) = number [1]total = 13 Persisting T1: n=31; T2: n=34; T3: n=33; T1-T2: n=31; T2-T3: n=33; T1-T2-T3: n=30)

Table 8.3.
Means and SDs of nonword repetition subtracted from word repetition (percentage of consonants correct)

	Speech disordered group	Control group
T1 discrepancy	1.02 (5.96)	2.42 (3.94)
T2 discrepancy	4.42 (6.56)	2.98 (4.62)
T2 (extension task) discrepancy	6.2 (7.59)	7.7 (6.7)
T3 (extension task) discrepancy	11.19 (6.94)	6.85 (6.93)

Z-scores were then created of these scores, using the controls' mean and SD. This enabled analysis of the word/nonword discrepancy of the speech disordered group in relation to the discrepancy occurring in the control group.

The z-scores of the speech disordered group were then subclassified at each testing phase as follows:

1. Subgroup 1 = children with z-scores within normal limits. This indicated that the discrepancy between word and nonword repetition is what one would expect from the control group mean and SD. A cut-off of +/- 1.5 SD was chosen rather than +/-1.0. This was to ensure the majority of the controls would fall within what had been classified as 'within normal limits'.
2. Subgroup 2 = children with z-scores greater than +1.5 SD. This indicated there was a bigger discrepancy between word and nonword repetition than was expected from the normative data.
3. Subgroup 3 = children with z-scores –1.5 SD or below. Children in this subgroup were performing better on nonword repetition than word repetition. This pattern reflected the 'frozen phonology' described by Bryan and Howard (1992).

While the majority of children in the speech disordered group followed a normal profile of performance, some children did have differing profiles. Children's profiles also changed over time, which could be partly due to task sensitivity. At T1, 21% of the speech disordered group had difficulties with lexical updating (Subgroup 3), but by T3, there were no children in this category. The pattern of word repetition being superior to nonword repetition (Subgroup 2) was still evident at T3.

Table 8.4.
Word/nonword discrepancy subgroups at T1 and T2 (original version)

	T1		T2	
	% (n) Speech disordered group	% (n) Control group	% (n) Speech disordered group	% (n) Control group
Like Controls	61.7 (29)	87.2 (41)	63.8 (30)	83 (39)
RW>NW	17 (8)	4.3 (2)	27.7 (13)	14.9 (7)
NW>RW	21.3 (10)	8.5 (4)	8.5 (4)	2.1 (1)

(n) = number of participants

Table 8.5.
Word/nonword discrepancy subgroups at T2 and T3 (extension task)

	T2		T3	
	% (n) Speech disordered group	% (n) Control group	% (n) Speech disordered group	% (n*) Control group
Like Controls	85.1 (40)	85.1 (40)	76.6 (36)	89.4 (42)
RW>NW	4.3 (2)	6.4 (3)	23.4 (11)	2.1 (1)
NW>RW	10.6 (5)	8.5 (4)	0 (0)	2.1 (1)

(n) = number of participants

* = n=44 (missing data)

The raw scores for each subgroup, as reported in Table 8.6, show that subgroup 2, (with a bigger discrepancy between word and nonword repetition than expected) actually show a word advantage, scoring better than subgroup 1 at T1 and at T2, on the extension tasks. They also show a nonword disadvantage compared to subgroup 1, on the original repetition task at T2 and the extension task at T3. Subgroup 3 is clearly the poorest overall in performance. Word repetition is consistently poorer than for the other two groups and nonword repetition is also poorer except at T1.

Table 8.6.
Means and SDs of word and nonword repetition by word/nonword discrepancy subgroups

	Subgroup 1		Subgroup 2		Subgroup 3	
	Word	Nonword	Word	Nonword	Word	Nonword
T1 repetition	50.56 (17.60) (n=29)	49.57 (17.22) (n=29)	57.14 (12.72) (n=8)	46.43 (12.41) (n=8)	39.35 (15.27) (n=10)	45.97 (14.43) (n=10)
T2 repetition	80.26 (20.28) (n=30)	77.53 (20.78) (n=30)	82.72 (18.10) (n=13)	70.33 (18.20) (n=13)	57.79 (13.18) (n=4)	66.56 (13.80) (n=4)
T2 LF repetition	67.45 (19.30) (n=40)	60.64 (17.88) (n=40)	87.50 (5.38) (n=2)	63.59 (11.53) (n=2)	37.69 (14.43) (n=5)	43.48 (14.40) (n=5)
T3 LF repetition	80.23 (14.59) (n=36)	71.90 (15.16) (n=36)	81.43 (7.37) (n=11)	60.89 (8.65) (n=11)	N/A	N/A

As numbers of children in each subgroup were not evenly distributed, subgroup distribution was analysed. First, subgroup size of the speech disordered and control groups was compared to see whether there was a greater incidence of subgroups 2 and 3 in the speech disordered group. This analysis was conducted separately for each testing phase.

The majority of the speech disordered group performed like the controls in that they showed a similar discrepancy between word and nonword repetition. At T1, 17% of the speech disordered group had a bigger discrepancy between word and nonword repetition than the controls. There was a significant difference in the proportion of speech disordered children classified into these 3 subgroups compared to the controls ($\chi^2(2) = 8.23$, $p<.01$) with less children classified as subgroup 1 (i.e. with a normal word/nonword discrepancy).

At T2, the proportion of children with a bigger discrepancy between word and nonword repetition than the controls varied depending on whether one considers the original repetition tasks or the extension task consisting of low frequency words and matched nonwords. There were very few children who showed this discrepancy in the extension task. For the control group, there was a bigger discrepancy between the word and nonword conditions on the extension task compared to the original task because some ceiling effects were noted on this original task and also the more difficult extension task produced a larger spread of scores. A probable explanation is therefore differences in task design, possibly due to the use of low frequency words. There was no significant difference between the control and speech disordered groups on subgroup membership (original version: $\chi^2(2) = 5.81$, ns; extension: $\chi^2(2) = .71$, ns). These Chi-square must be treated with caution, as the expected count was less than 5 on some cells.

The pattern at T3 follows that of T1 and T2 (original version), with 23% showing a larger than expected discrepancy between word and nonword repetition. However, at T3, there were no children who showed the opposite pattern of being better at nonwords than words. There was a significant difference between subgroups ($\chi^2(2) = 9.71$, $p<.01$). However, because the expected count was less than 5 on some cells, results must be treated with caution.

8.2.3. Stability of category membership according to word/nonword discrepancy

There was lack of stability of category membership across time. Examination of the classification system showed that only 14 children (29.8% of the group) were classified as Subgroup 1, i.e. 'like controls', over all the testing phases and on both the original and extension tasks at T2. No children retained membership of Subgroups 2 or 3 over all tests and test phases, i.e. there was movement between Subgroups 1, 2 and 3. Subgroup 1 remained the largest subgroup at each testing phase, with 62-85% of the sample being classified in this category. The number of children classified as Subgroup 3 generally decreased over time, with no incidence at T3.

8.2.4. What is the relationship between word/nonword profile and speech performance?

Type of profile was calculated according to whether children's speech had resolved by T3, as reported in Tables 8.7 and 8.8. As reported in Chapter 6, 28% (n=13) of the speech disordered group had normal speech on a composite measure of the speech tasks at T3. Children whose speech had resolved by T3 tended to have a normal profile of word/nonword discrepancy. A third of children (ranging from 33-38%) with a normal profile of word/nonword discrepancy went on to have normal speech performance. Those with different profiles had a poorer outcome. For example, of the 11 children who had a larger than expected discrepancy between word and nonword repetition at T3, only 1 had resolved speech at T3. These may reflect the findings reported in Chapter 7, showing an increasing discrepancy emerging between word and nonword repetition for the persisting speech subgroup between T2 and T3. In addition, there was an increase between T2 and T3 from two to ten children in the persisting speech subgroup who had a greater than expected word/nonword discrepancy.

Fisher's Exact test verified the relationship between word/nonword profile and speech outcome at only one time point. For this analysis, subgroup 2 and subgroup 3 were collapsed due to small numbers. At T1, there was a significant difference at $p<.05$ between the groups (i.e. whether normal or atypical word/nonword profile) on whether they were more likely to be classified as having resolved speech or not at T3. However, there was no significant difference between the groups at any other time point.

Examining instability of word/nonword profile in relation to speech outcome showed a more clear-cut result. Instability of word/nonword profile was greater for the persisting speech subgroup than the resolved speech subgroup. A Chi-square found a significant difference between the subgroups on the proportion of children showing a stable profile in line with the controls, and a profile that changed over time (χ^2 (1) = 9.91, $p<.005$). This result is illustrated in the Pie Charts in Figures 8.3 and 8.4.

Table 8.7.
Percentage of children in each word/nonword discrepancy subgroup by Speech outcome subgroup

	% Like Control group (n)		% RW>NW (n)		% NW>RW (n)		% Different profile to Control group (n)	
	Resolved[1]	Persisting[2]	Resolved[1]	Persisting[2]	Resolved[1]	Persisting[2]	Resolved[1]	Persisting[2]
T1	84.6 (11)	52.9 (18)	7.7 (1)	20.6 (7)	7.7 (1)	26.5 (9)	15.4 (2)	44.1 (15)
T2 (original version)	76.7 (10)	58.8 (20)	23.1 (3)	29.4 (10)	0 (0)	11.8 (4)	23.1 (3)	41.2 (14)
T2 (extension)	100 (13)	79.4 (27)	0 (0)	5.9 (2)	0 (0)	14.7 (5)	0 (0)	20.6 (7)
T3	92.3 (12)	70.6 (24)	7.7 (1)	29.4 (10)	0 (0)	0 (0)	7.7 (1)	29.4 (10)
T1-T2 (original version)	69.2 (9)	29.4 (10)	0 (0)	8.8 (3)	0 (0)	2.9 (1)	0 (0)	11.8 (4)
T2-T3 (extension)	92.3 (12)	52.9 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
T1-T2-T3 (all versions)	69.2 (9)	20.6 (7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

(n) = number
[1] total = 13
[2] total = 34

Table 8.8.
Percentage of children whose speech had resolved at T3 by word/nonword discrepancy subgroup

	% of subgroup 1 with resolved speech	% of subgroup 2 with resolved speech	% of subgroup 3 with resolved speech
T1	37.9% (11/29)	12.5% (1/8)	10% (1/10)
T2 (original)	33.3% (10/30)	23.1% (3/13)	0% (0/4)
T2 (extension)	32.5% (13/40)	0% (0/2)	0% (0/5)
T3	33.3% (12/36)	9.1% (1/11)	0% (0/0)

Figure 8.3.
Pie Chart showing proportion with stable/changing word/nonword profile between T1 and T3: Resolved speech subgroup

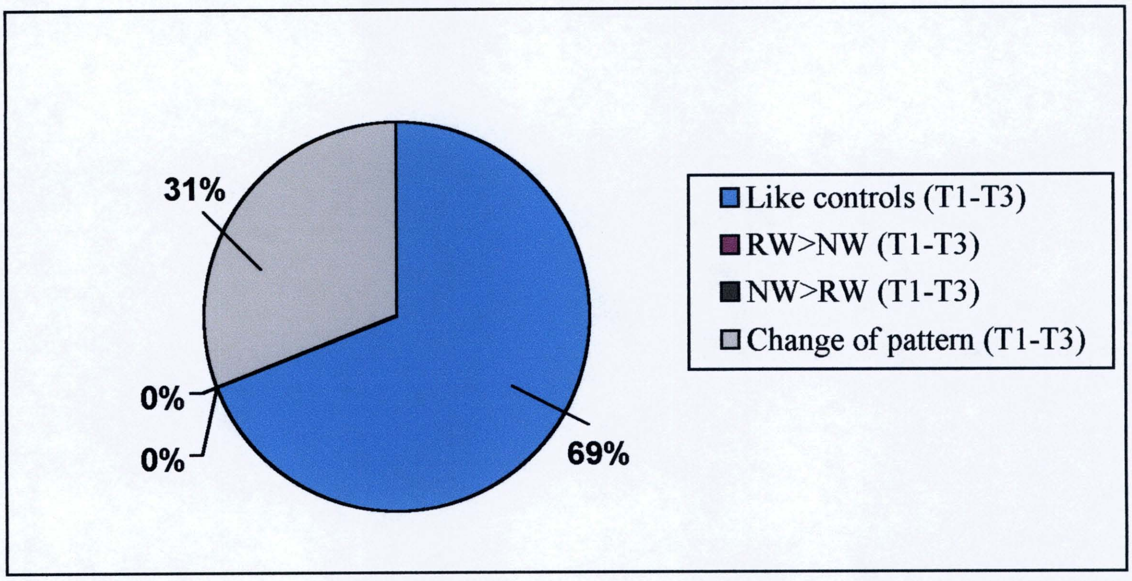
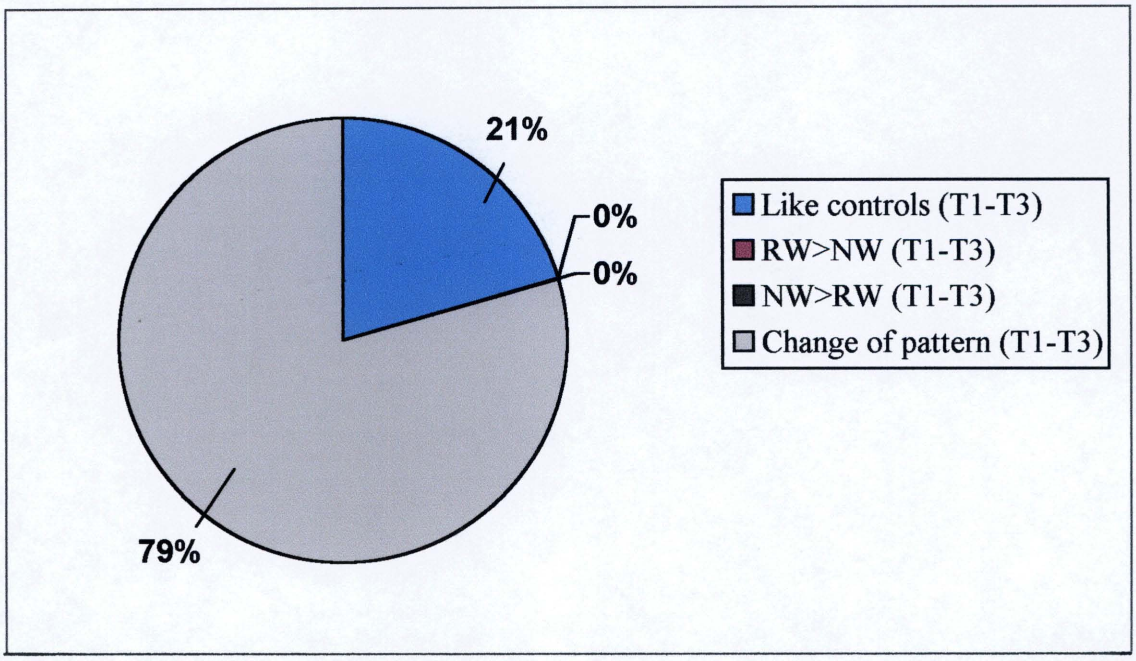


Figure 8.4.
Pie Chart showing proportion with stable/changing word/nonword profile between T1 and T3: Persisting speech subgroup



8.2.5. The relative contribution of AD: ABX task and AD: picture task to speech output skills: Concurrent relationship

This analysis examined the relative contribution of different speech input processing levels to speech production. The AD: ABX task and AD: picture task were compared in their strength of relationship with the speech output tasks. An extensive correlational analysis of both concurrent and longitudinal relationships was carried out, and is discussed in the next chapter. Specific relationships predicted from Stackhouse and Wells' (1997) model are examined here.

A series of hierarchical multiple regressions was carried out to ascertain the relative contribution of these two speech input tasks to different speech output tasks concurrently. The order of the two speech input tasks in the regression model was varied in order to assess the hypotheses outlined in the introduction:

1. The AD: picture test will predict unique variance in word repetition.
2. The AD: picture task will predict unique variance in articulatory naming.
3. The AD: ABX task will predict unique variance in nonword repetition.

The speech output tasks were not entered as predictors in these analyses, as these analyses specifically compared how well the two speech input measures predicted speech output. Regressions were carried out at each testing phase, T1, T2 and T3, looking at the speech disordered group and the matched controls separately. Raw scores, and, in the case of the speech input tasks, *d'* scores, were converted to z-scores according to each group's mean and SD. At T2, a composite was made of the two word repetition tasks and, similarly, of the two nonword repetition tasks. The results are reported in Tables 8.9-8.11 below and summarised here and in Figures 8.5 and 8.6. The two speech input tasks accounted for significant amounts of variance in word repetition and nonword repetition tasks for both groups at all testing phases. The two speech input tasks also predicted unique variance in articulatory naming at T1 and T2 for both the speech disordered group and at T1 for the control group. However, they predicted no significant variance in naming at T3 for the speech disordered group or at T2 or T3 for the control group.

Adjusted R^2 scores show that, for the speech disordered group, the amount of variance that the speech input tasks collectively accounted for dropped between T2 and T3 for the word repetition task (from 28% to 17%) and articulatory naming task (from 23% to 7%). It also decreased gradually over the three testing phases for nonword repetition (from 34% at T1, to 27% at T2 and 17% at T3).

For the control group, the pattern was different. Adjusted R^2 decreased between T1 and T2. At T3, speech input skills accounted for 29% of variance in word repetition, compared to 13% a year earlier. It accounted for 45% of variance in nonword repetition compared to 15% a year earlier. But it accounted for only 7% of the variance in articulatory naming.

The relationships between the two speech input tasks and the three speech output tasks seem to differ as a function of age and of speech status. The relationships are different at different testing phases and also differ depending on whether one looks at the speech disordered group or the control group.

At T1, results are uniform across speech output tasks and between groups. The AD: picture task predicts unique variance in word repetition, nonword repetition and articulatory naming. The AD: ABX task does not predict any unique variance, i.e. it is not predictive when entered at the last step.

At T2, a different pattern of performance is shown, both depending on the speech output task and on group membership. For the speech disordered group, the AD: picture task predicts unique variance in word repetition, but just misses reaching significance in nonword repetition and is not a significant predictor in articulatory naming. On the other hand, the AD: ABX task predicts some unique variance in nonword repetition (just significant at 8% at the last step) and articulatory naming (also just significant at 9% of the variance) but just misses reaching significance in word repetition. Compared to the results at T1, this shows a mixed performance.

The pattern for controls at T2 is again slightly different. There is shared variance between the two speech input tasks in the prediction of word repetition with neither task predicting significant unique variance. However, for nonword repetition, there seems to be a more clear-cut result with the AD: picture task predicting 10% of unique variance at the last step compared to only 2% for the AD: ABX task. A speech input task that purports to measure internal, stored phonological representations is found to be predictive of a task where a child must produce a novel item that has no stored information. The articulatory naming task shares little relationship with the input tasks.

At T3, the pattern is once again different. For the speech disordered group, the AD: ABX task is highly predictive of word and nonword repetition, whilst nothing is predictive of articulatory naming. Whilst the controls follow a similar pattern for word repetition and articulatory naming, they differ on nonword repetition where the AD: picture task is highly predictive.

Table 8.9.

Hierarchical multiple regression of T1 measures predicting speech output measures at T1

	Variables entered	Speech disordered					Control group				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: RWpcc										
Step 1	AD: Pic	.25	.23	.25	13.63	**<.001**	.26	.24	.26	15.18	**.<001**
Step 2	AD: ABX	.31	.28	.07	4.02	.052	.26	.22	.002	.12	ns
Step 1	AD: ABX	.11	.08	.11	4.97	**<.05**	.07	.05	.07	3.43	.07
Step 2	AD: Pic	.31	.28	.21	12.32	**<.001**	.26	.22	.19	10.80	**<.005**
	DV: NWpcc										
Step 1	AD: Pic	.32	.30	.32	19.52	**<.001**	.30	.29	.30	19.15	**<.001**
Step 2	AD: ABX	.37	.34	.05	3.44	.07	.32	.29	.02	.92	ns
Step 1	AD: ABX	.09	.07	.09	4.31	**<.05**	.13	.11	.13	6.37	**<.05**
Step 2	AD: Pic	.37	.34	.28	18.03	**<.001**	.32	.29	.19	12.06	**<.001**
	DV: Artic Naming										
Step 1	AD: Pic	.24	.22	.24	13.23	**<.001**	.33	.31	.33	21.47	**<.001**
Step 2	AD: ABX	.28	.25	.04	2.34	ns	.33	.30	.004	.28	ns
Step 1	AD: ABX	.07	.05	.07	3.25	.08	.10	.08	.10	4.91	**<.05**
Step 2	AD: Pic	.28	.25	.21	11.90	**<.001**	.33	.30	.23	14.93	**<.001**

Note:
DV dependent variable

Table 8.10.

Hierarchical multiple regression of T2 measures predicting speech output measures at T2

	Variables entered	Speech disordered					Control group				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: RWpcc										
Step 1	AD: Pic	.25	.23	.25	14.97	**<.001**	.15	.13	.15	7.44	**<.01**
Step 2	AD: ABX	.31	.28	.06	4.03	.051	.17	.13	.03	1.44	ns
Step 1	AD: ABX	.23	.22	.23	13.72	**<.001**	.10	.08	.10	4.63	**<.05**
Step 2	AD: Pic	.31	.28	.08	5.05	**<.05**	.17	.13	.08	4.01	.052
	DV: NWpcc										
Step 1	AD: Pic	.22	.21	.22	12.83	**<.001**	.17	.15	.17	8.89	**<.005**
Step 2	AD: ABX	.30	.27	.08	4.93	**<.05**	.19	.15	.02	1.17	ns
Step 1	AD: ABX	.24	.23	.24	14.37	**<.001**	.09	.07	.09	4.49	**<.05**
Step 2	AD: Pic	.30	.27	.06	3.66	.06	.19	.15	.10	5.18	**<.05**
	DV: Artic Naming										
Step 1	AD: Pic	.17	.15	.17	9.29	**<.005**	.002	-.02	.002	.10	ns
Step 2	AD: ABX	.26	.23	.09	5.21	**<.05**	.003	-.04	.001	.05	ns
Step 1	AD: ABX	.23	.21	.23	13.06	**<.001**	.00	-.04	.00	.006	ns
Step 2	AD: Pic	.26	.23	.03	2.02	ns	.003	-.04	.003	.14	ns

Note:
DV dependent variable
RWpcc and NWpcc are composites of the original and extension tasks

Table 8.11.

Hierarchical multiple regression of T3 measures predicting speech output measures at T3

	Variables entered	Speech disordered					Control group				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: RWpcc										
Step 1	AD: Pic	.01	-.01	.01	.58	ns	.12	.10	.12	5.72	**<.05**
Step 2	AD: ABX	.21	.17	.20	10.62	**<.005**	.33	.29	.20	12.13	**<.001**
Step 1	AD: ABX	.20	.19	.20	11.30	**<.005**	.29	.27	.29	16.76	**<.001**
Step 2	AD: Pic	.21	.17	.00	.23	ns	.33	.29	.04	2.17	ns
	DV: NWpcc										
Step 1	AD: Pic	.02	-.01	.02	.74	ns	.46	.44	.46	34.29	**<.001**
Step 2	AD: ABX	.21	.17	.19	10.53	**<.005**	.47	.45	.02	1.27	ns
Step 1	AD: ABX	.2	.19	.21	11.52	**<.001**	.11	.09	.11	5.15	**<.05**
Step 2	AD: Pic	.21	.17	.00	.14	ns	.47	.45	.36	27.33	**<.001**
	DV: Artic Naming										
Step 1	AD: Pic	.01	-.01	.01	.63	ns	.07	.04	.07	2.89	ns
Step 2	AD: ABX	.05	.007	.04	1.68	ns	.11	.07	.05	2.09	ns
Step 1	AD: ABX	.05	.03	.05	2.31	ns	.08	.06	.08	3.62	.06
Step 2	AD: Pic	.05	.007	.00	.06	ns	.11	.07	.03	1.40	ns

Note:
DV dependent variable

8.2.6. The relative contribution of AD: ABX task and AD: picture task to speech output skills: Longitudinal relationship

A similar analysis was conducted looking at the contribution of the two speech input tasks to later speech output performance. Regressions were calculated looking at T1 speech input performance in relation to T2 speech output, as well as T1 speech input with T3 speech output and T2 speech input with T3 speech output. Results are reported in Tables 8.12-8.14 and in Figures 8.7 and 8.8. The two speech input tasks accounted for variance longitudinally in measures of word repetition and nonword repetition tasks for both groups at all testing phases. The two speech input tasks also predicted unique variance in articulatory naming for the speech disordered group but for the control group only at T1. The speech input measures at T1 predicted variance in later measures of speech output (T2 and T3).

Inspection of R^2 shows that comparable amounts of variance are accounted for in the T1 measures' prediction of repetition tasks as in the concurrent regression analyses reported above. The concurrent and longitudinal analyses differ in one respect. T2 measures of speech input seem to predict quite substantial amounts of variance in T3 speech output measures, for the speech disordered group. They predict over half the variance in word repetition (.54) and large amounts in nonword repetition (.36) and articulatory naming (.44). This may partly reflect the fact that these speech input tasks vary in their sensitivity over time, as previously discussed. However, it is important to note that level of speech input performance at T2 is predictive of speech output skills a year later, and that this causal relationship is stronger than the relationship between speech output and speech input skills measured at the same age.

Turning to the relative contribution of the two speech input skills, the results are less clear-cut, with the two tasks being predictive to different extents at different ages and according to group membership.

For the control group, the AD: picture task features more often as a predictor than the AD: ABX task (with the exception of naming where no predictors emerge). As this task predicts variance in nonword repetition as well as word repetition, there is support for the argument that the AD: picture task taps a broader measure of speech input processing than just phonological representations.

For the speech disordered group, there are different patterns of prediction. The AD: picture task consistently predicts unique variance in articulatory naming. Here it seems one could put forward an explanation that the accuracy of stored phonological representations is related to articulatory naming skills. For the other tasks, however, both speech input tasks are predictive at different points. At times, both show unique variance (T1-T2 nonword repetition; T2-T3 word repetition).

Table 8.12.

Hierarchical multiple regression of T1 measures predicting speech output measures at T2

	Variables entered	Speech disordered					Control group				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: RWpcc										
Step 1	AD: Pic	.25	.23	.25	14.02	**<.001**	.34	.32	.34	22.53	**<.001**
Step 2	AD: ABX	.29	.25	.04	2.19	ns	.36	.33	.02	1.37	ns
Step 1	AD: ABX	.07	.05	.07	3.09	ns	.15	.13	.15	7.89	**<.01**
Step 2	AD: Pic	.29	.25	.22	12.66	**<.001**	.36	.33	.21	13.90	**<.001**
	DV: NWpcc										
Step 1	AD: Pic	.23	.21	.23	12.72	**<.001**	.18	.16	.18	9.82	**<.005**
Step 2	AD: ABX	.32	.28	.08	5.04	**<.05**	.22	.19	.04	2.16	ns
Step 1	AD: ABX	.13	.10	.13	5.99	**<.05**	.14	.12	.14	6.93	**<.05**
Step 2	AD: Pic	.32	.28	.19	11.49	**<.005**	.22	.19	.09	4.72	**<.05**
	DV: Artic Naming										
Step 1	AD: Pic	.20	.19	.20	10.77	**<.005**	.001	-.02	.001	.04	ns
Step 2	AD: ABX	.24	.21	.04	2.12	ns	.003	-.04	.00	.11	ns
Step 1	AD: ABX	.07	.04	.07	2.99	ns	.003	-.02	.00	.15	ns
Step 2	AD: Pic	.24	.21	.18	9.57	**<.005**	.003	-.04	.00	.00	ns

Note:
DV dependent variable

Table 8.13.

Hierarchical multiple regression of T1 measures predicting speech output measures at T3

	Variables entered	Speech disordered					Control group				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: RWpcc										
Step 1	AD: Pic	.25	.23	.25	13.61	**<.001**	.42	.41	.42	29.83	**<.001**
Step 2	AD: ABX	.30	.27	.06	3.4	.07	.42	.39	.00	.02	ns
Step 1	AD: ABX	.09	.07	.09	4.35	**<.05**	.08	.06	.08	3.59	.07
Step 2	AD: Pic	.30	.27	.21	12.27	**<.001**	.42	.39	.34	23.56	**<.001**
	DV: NWpcc										
Step 1	AD: Pic	.19	.17	.19	9.68	**<.005**	.16	.14	.16	7.94	**<.01**
Step 2	AD: ABX	.29	.26	.10	5.89	**<.05**	.21	.17	.05	2.51	ns
Step 1	AD: ABX	.14	.12	.14	6.91	**<.05**	.15	.13	.15	7.02	**<.05**
Step 2	AD: Pic	.29	.26	.15	8.54	**<.01**	.21	.17	.07	3.33	.08
	DV: Artic Naming										
Step 1	AD: Pic	.19	.17	.19	9.92	**<.05**	.01	-.03	.01	.57	ns
Step 2	AD: ABX	.21	.17	.02	.83	ns	.02	-.03	.01	.36	ns
Step 1	AD: ABX	.04	.01	.04	1.50	ns	.02	-.03	.02	.78	ns
Step 2	AD: Pic	.21	.17	.17	8.93	**<.005**	.02	-.03	.00	.15	ns

Note:
DV dependent variable

Table 8.14.

Hierarchical multiple regression of T2 measures predicting speech output measures at T3

	Variables entered	Speech disordered					Control group				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: RWpcc										
Step 1	AD: Pic	.38	.37	.38	27.75	**<.001**	.36	.34	.36	22.84	**<.001**
Step 2	AD: ABX	.56	.54	.18	17.52	**<.001**	.41	.38	.05	3.50	.07
Step 1	AD: ABX	.48	.46	.48	40.71	**<.001**	.21	.19	.21	10.90	**<.005**
Step 2	AD: Pic	.56	.54	.08	8.22	**<.01**	.41	.38	.20	13.50	**<.001**
	DV: NWpcc										
Step 1	AD: Pic	.19	.17	.19	10.62	**<.05**	.22	.20	.22	11.76	**<.001**
Step 2	AD: ABX	.38	.36	.19	13.73	**<.001**	.30	.27	.08	4.56	**<.05**
Step 1	AD: ABX	.37	.35	.37	26.14	**<.001**	.21	.19	.21	10.70	**<.005**
Step 2	AD: Pic	.38	.36	.02	1.13	ns	.30	.27	.10	5.48	**<.05**
	DV: Artic Naming										
Step 1	AD: Pic	.44	.43	.44	35.98	**<.001**	.02	-.01	.02	.61	ns
Step 2	AD: ABX	.46	.44	.02	1.41	ns	.04	-.01	.03	1.07	ns
Step 1	AD: ABX	.23	.21	.23	13.07	**<.001**	.04	.02	.04	1.64	ns
Step 2	AD: Pic	.46	.44	.24	19.32	**<.001**	.04	-.01	.00	.08	ns

Note:
DV dependent variable

Figure 8.5.
Summary of unique predictors in multiple regression analyses: Concurrent relationships between input tasks and the three output tasks for the Speech disordered group

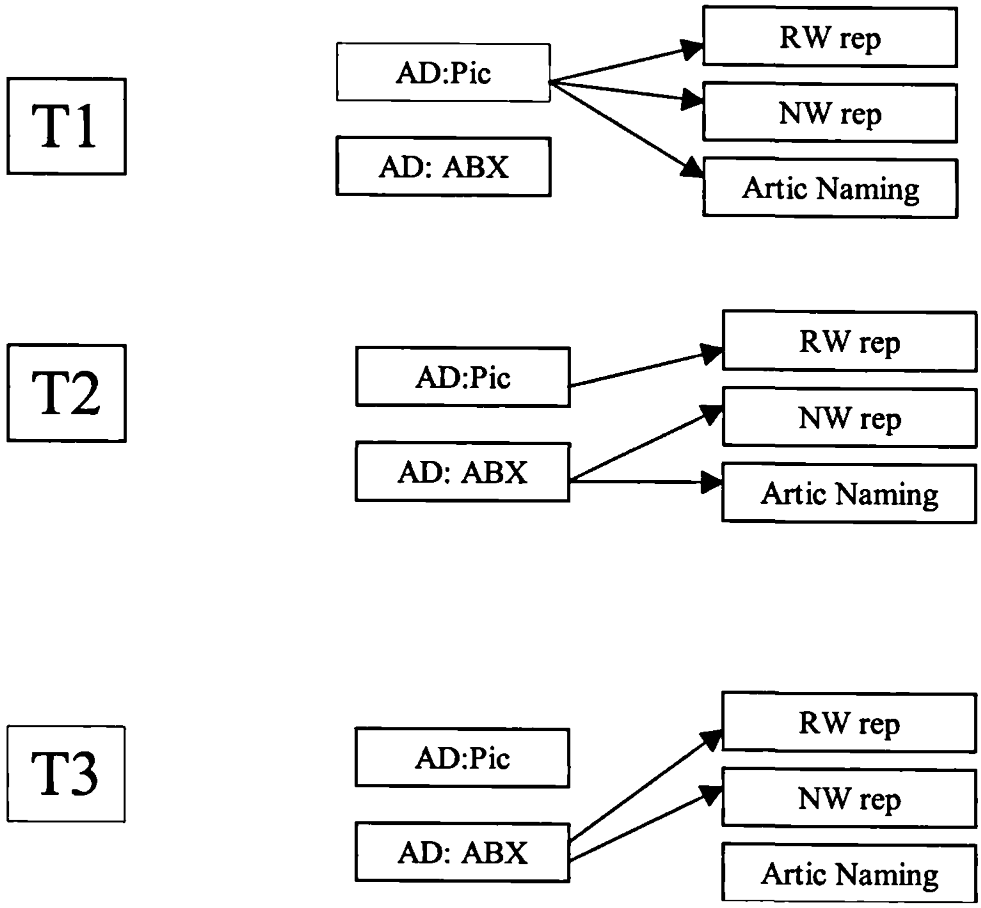


Figure 8.6.
Summary of unique predictors in multiple regression analyses: Concurrent relationships between input tasks and the three output tasks for the Control group

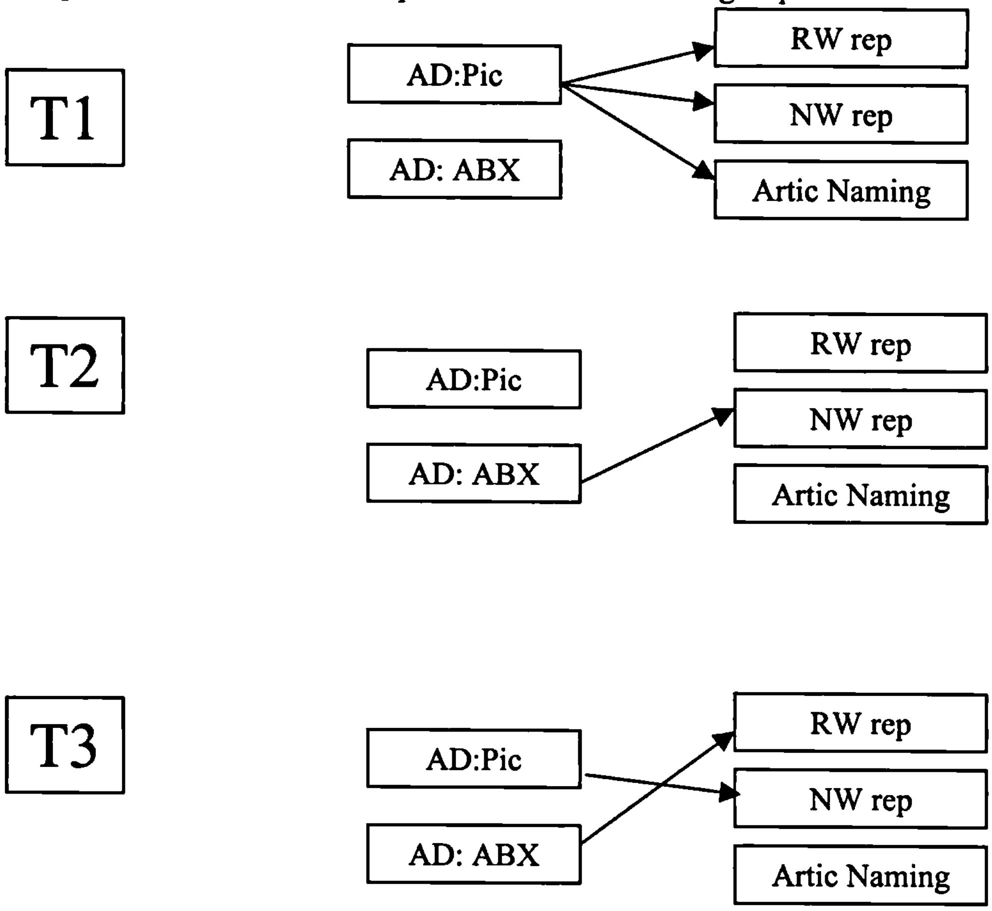


Figure 8.7.
Summary of unique predictors in multiple regression analyses: Longitudinal relationships between input tasks and the three output tasks for the Speech disordered group

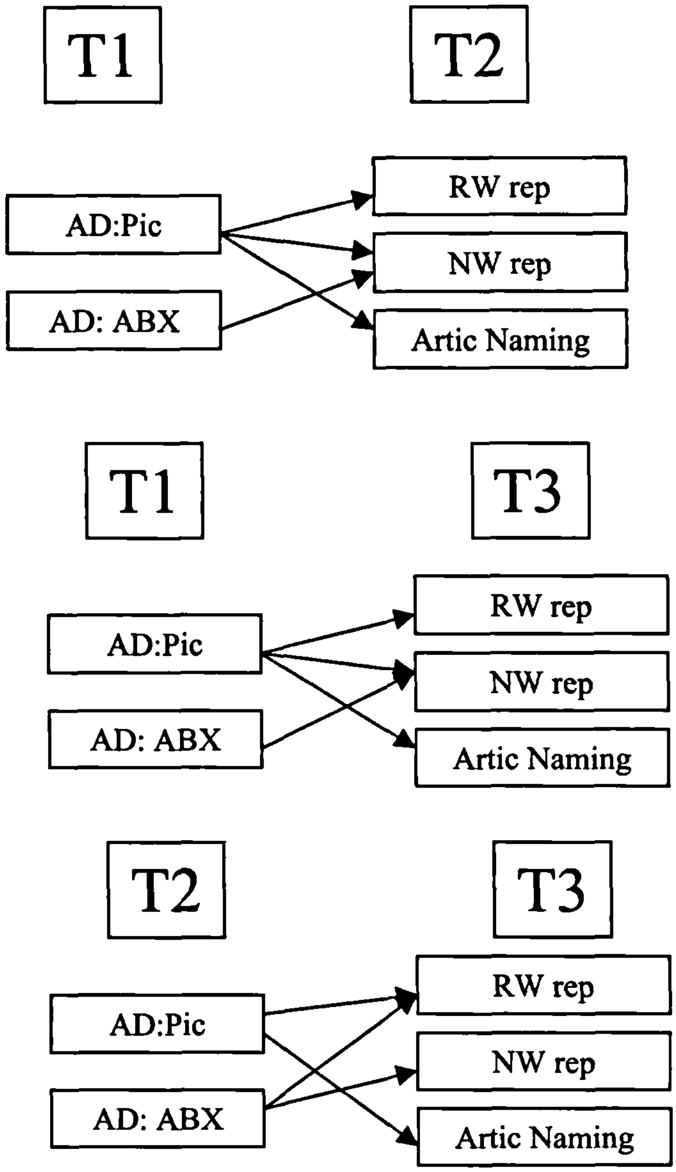
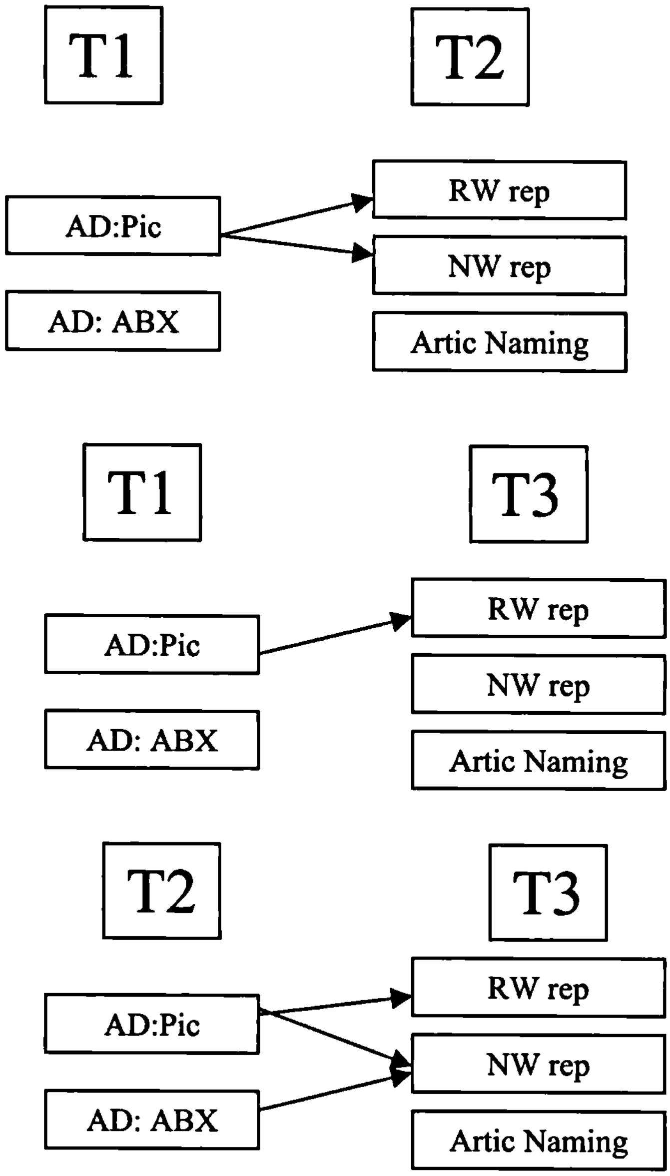


Figure 8.8.
Summary of unique predictors in multiple regression analyses: Longitudinal relationships between input tasks and the three output tasks for the Control group



8.3. Discussion

8.3.1. Processing profiles on the speech input tasks

Dissociation between input and output processing deficits was confirmed by the finding that over half of the sample performed age appropriately at each testing phase on speech input tasks, i.e. they did not have any deficits on the Auditory discrimination tasks[6]. Of those children who did have input processing difficulties, some showed a dissociation between the levels of phonological recognition and phonological representation, whilst other children showed deficits on both tasks.

No one identifiable pattern of deficit was found that persists across different testing phases. Lack of consistent deficits over time reflects the changing patterns observed in normal development as well as task sensitivity. At T1, children with speech difficulties show more specific deficits with the AD: picture task and less with the AD: ABX task. This also reflects the control group's pattern, with more chance effects observed in the AD: ABX task. As the AD: picture task reaches ceiling at T3, and the AD: ABX task becomes increasingly sensitive, less specific deficits are observed on the former task, whilst more children show specific deficit on the latter, again reflecting the control group's pattern of performance on the two tasks. However, patterns of performance were not completely mediated by task sensitivity, as some children showed specific deficits on tasks where the majority were performing at chance or ceiling. For example, at T1 and T2 some showed deficits with phonological recognition but not phonological representations, and at T3 some were age-appropriate on phonological recognition but not phonological representations.

The fine-grained analysis between the levels of phonological recognition and phonological representations failed to find a persisting deficit across the group and over time that might be causal to these children's speech difficulties. It is possible, however, that earlier difficulties in these areas did exist (before these measures were taken) and that these earlier difficulties are related to present performance. Alternatively, the tests may not have been sensitive enough to pick up subtle differences that could have been uncovered if, for example, assessments were designed using the child's errors (as

[6] Note: Proportions reported here vary from those reported in Chapter 7 as here, a composite score was created of AD: ABX and AD: same/different.

recommended by Locke, 1980). However, as the result stands, it seems that this proportion of the group must have deficits solely on speech output skills. It is argued that children with both input and output difficulties are more likely to have persisting problems. Children whose difficulties resolve by T3 were more likely to show no input processing deficits at any time point (62% of the resolved group (8/12) exhibited no input processing deficits) compared to children whose problems persisted (only 23% of this group (7/30) were spared of input processing deficits).

8.3.2. Performance on word and nonword repetition

Confirming the results of the ANOVAS reported in Chapter 4, it was found that the majority of children with speech difficulties have a word/nonword profile like controls, i.e. their performance on word repetition is slightly better than their performance on nonword repetition. However, some children in both groups were found to have different patterns of performance. At T1, there was a significant proportion of children with speech difficulties who had a word/nonword profile different from controls. At T2, there was no significant difference between the groups in category membership, and at T3, numbers were too small to be conclusive about a different pattern of performance.

Some children in the speech disordered group displayed pattern 2, i.e. they had a greater word/nonword discrepancy than predicted, and this pattern was noted in some children at each testing phase. Inspection of the means on the repetition tasks showed that these children were showing a word advantage over children exhibiting patterns 1 and 3, rather than a nonword disadvantage. Stackhouse and Wells (1997) suggested that such a pattern indicates problems creating a motor program for a new word. This may be the case within their own system, but compared to other children with speech difficulties, they appear to be superior at word repetition, where stored phonological representations and motor programs can be accessed, and not relatively impaired on nonword repetition, where new motor programs must be created. However, much variability was apparent within these patterns of performance.

Some children displayed pattern 3, i.e. nonword repetition was better than word repetition. Interestingly, however, this pattern was only observed in children with speech difficulties at T1 and T2. Furthermore, since the majority of the children were actually performing like controls, it seems that the cases reported in the literature by Bryan and Howard (1992) and Hewlett et al. (1998) are exceptional. Children who were better at nonword repetition than word repetition at T1 and T2 seemed to have poorer speech output skills than children exhibiting the other patterns of performance.

Specific patterns of word/nonword performance were not closely related to speech development. It was not clear that specific, identifiable problems with lexical updating (i.e. difficulty with stored representations, but better on-line processing) were related to speech outcome. However, there was some indication that a different pattern of performance early on at T1 was related to a greater likelihood of persisting speech difficulties at T3. In addition, children with persisting speech difficulties were more likely to have an unstable profile over time. Children whose speech difficulties resolved were more likely to have a stable profile which was in line with the controls' performance. Therefore *changes* in pattern of performance on word/nonword repetition are argued to reveal differences between the speech outcome subgroups. Changes in profile were also found to be of importance in Chapter 7 when some children with persisting speech difficulties showed a relative lack of improvement on nonword repetition, indicating possible motor programming deficits.

Examining snapshots of word/nonword profile therefore revealed instability. Many children seemed to move between categories over time and also showed different profiles depending on which matched word/nonword task was considered. This lack of stability shows that one cannot locate a particular processing deficit at one time point that is, in some sense, a cause of the speech difficulty. Rather, the analyses show that one may be able to highlight particular processing difficulties at one age but that these will not necessarily be replicated later on. Thus the approach can be said to describe the development of a child's speech processing system, rather than be explanatory of the speech disorder, or uncover its underlying nature. The lack of stability found shows that the nature of these children's speech processing systems is, in essence, changing, a result of the interaction between these different levels in the continuing development of the speech processing system. Looking at development more directly is a more fruitful way to explore this instability (e.g. word/nonword performance over time explored in Chapters 4 and 7, and relationships between tasks, explored in Chapter 9).

This analysis shows that children with speech difficulties are not only heterogeneous in their speech and language skills, but they also show variable speech processing patterns within their own individual speech processing systems over time. This is the case when making a broad division between input and output skills and at a more fine-grained level that differentiates between phonological recognition and phonological representations, and between word or nonword advantage in repetition performance. What this analysis might miss, however, is that deficits could have been found if it had been possible to assess these patterns of performance using each child's own errors, i.e. examining processing profiles on an item-by-item basis rather than using a general assessment that tests a wide range of features. Such an analysis would itself raise problems: for example, would one design a new test for the child's errors for each testing phase (in which case, one is not comparing the same stimuli over time) or examine changes in performance on historical errors?

This lack of stability in speech processing profile is to be expected given the unfolding nature of the deficit. The changes in task sensitivity are merely a reflection of these developmental changes in processing ability, rather than a separate methodological issue. The longitudinal multiple regressions examine the relationships between variables over time and so address individual difference in children's development. These results will be discussed in conjunction with the examination of concurrent relationships. Both the concurrent and longitudinal analyses examine relative associations between variables which might be predicted from Stackhouse and Wells' speech processing model.

8.3.3. The relationship of skills at the level of 'phonological recognition' and 'phonological representation' with speech output skills

The results of the multiple regressions will now be discussed. First, the concurrent relationship between the two levels of speech input processing and speech output measures will be examined.

At T1, the AD: picture task was highly predictive of the three speech output tasks for both groups. The AD: ABX task's lack of prediction is likely to be due to task sensitivity. We therefore cannot contrast the relative contribution of the two auditory tasks at T1. Since the stored representations (which the AD: picture task taps) are formed from the lower level skill of 'phonological recognition', one would not wish to rule out the possibility of bottom-up processing occurring either concurrently, but undetected by the measures used, or historically, in the formation of these stored representations.

At T2, it is not clear which speech input measures best predict speech output measures, as speech input tasks just miss significance or just reach an acceptable significance level. However, it is worth noting that the two tasks do, at times, predict unique variance: the tasks may therefore be tapping different and separable processing levels. Speech input skills are again shown to play an important concurrent role in the speech processing system.

These regressions of concurrent relationships appear somewhat inconclusive as regards which kinds of speech input skills relate most closely to different speech output tasks. There are, however, some patterns that emerged that are worth further interpretation. For the control group, the AD: picture task is predictive of nonword repetition at all testing phases (although we have decided to discount the result at T1 because of the poor sensitivity of the ABX task). This finding is a surprise given the prediction of the model by Stackhouse and Wells. That a task purported to measure stored phonological representations is related to a nonword task where there are, by definition, no stored representations for the stimuli, is puzzling. One explanation is that stored information and thus, top-down processing, does play a role in nonword repetition. It is possible that the children are accessing a word analogy from their phonological store when they process the nonword. Also possible is that the AD: picture task does not in fact primarily tap phonological representations, but reflects broader perceptual abilities. Certainly, according to Stackhouse and Wells' model, 'phonological recognition' is also implicated in this task. The skills that are being assessed in this task could be skills involved in the lower level phonological store, and not specifically related to the lexical store. However, one would then need to account for the different way the tasks predict speech output skill. It has been recognised that, although it may be useful to separate out these components, it is problematic:

"*Theoretically, the separation of phonological storage processes from other phonological processes (such as segmentation, blending and articulatory assembly) may prove very difficult.*" (Snowling, Chiat & Hulme, 1991, p. 373)

The relationship found suggests that the skill of repeating nonwords could involve representational levels. Stackhouse and Wells propose that both a temporary motor program and a new phonological representation must be created in order to repeat a nonword. The ability to do this must be related to the extent of the previous success in storing phonological representations accurately, as measured by the AD: picture task which assessed accuracy of a pre-existing representation. For controls, the strong relationship between AD: picture and nonword repetition suggests that the representational level is implicated more than lower level auditory discrimination problems in the process of nonword repetition. For the speech disordered group, the emphasis is a little different with the AD: ABX being more predictive of nonword repetition than the AD: picture task. Deficits were noted on both these speech input tasks in the speech disordered group. nonword repetition does require lower level auditory discrimination skill and this skill precedes the creation of a new representation (if a child cannot discriminate between sounds, they are unlikely to be able to form representations accurately). Thus, deficits on lower level auditory discrimination would be consistent with a strong relationship between AD: ABX task and nonword repetition.

The pattern of predictors for articulatory naming also needs consideration. For the control group (apart from at T1) there is no significant relationship between input tasks and the ability to retrieve, access and articulate a word. The naming task was not matched to the repetition tasks, which limits the conclusions that can be drawn. However, it could be hypothesised that, for controls, there is a dissociation between the skill of naming and input processing, but that when spoken words are heard for a repetition task, a child will utilise input processing to a greater extent. But it cannot be argued that there is a more specific dissociation between naming, involving the accessing of motor programs, and phonological representations, as tested in the AD: picture task. This proposal would run contrary to the argument previously given, that there may be very close relationships between these levels of representation (because of the predictive relationship between AD: picture task and nonword repetition), which was found in the speech disordered group, but also the control group. Correlations reported in the next chapter also show some significant correlations between naming and other output measures for the control group, though not to the same degree as between the repetition tasks. Results from longitudinal correlations (also reported in Chapter 9), which found that articulatory naming did not correlate with itself over time raises serious concerns with this measure (discussed again, in Chapter 9), suggesting caution should be applied in forming an interpretation.

Turning to the other longitudinal analyses, some similar patterns of performance were observed. One interesting difference was also noted. Taking speech input measures overall, at T2 they showed a greater predictive relationship with speech output measures a year later, at T3, than with concurrent (T2) speech output measures (though these were still significant). This finding strengthens the argument that these speech input measures reflect the importance of input processing to the overall speech processing system in children with normal and atypical speech and that it seems to play an important role in the further development of this system. However, as speech output skills were not entered in the regression, it is not possible to draw conclusions about the relative contribution of input and output skills, an issue that is explored in Chapter 9. Comparison of the different speech input measures as predictors of speech output did not show any clear-cut patterns. If one takes the view that the speech input tasks are actually tapping different skills, then one could argue that both top-down and bottom-up processing are important in the development of speech skills. Alternatively, task sensitivity and the shared processing levels of the AD: picture task could explain the difficulty of analysing the different contributions of the two input processing levels. The lack of a clear-cut pattern is evidence for an interactive processing system, especially when examining the developmental perspective.

8.3.4. The developing system

The proposition of downstream effects allows for a modular explanation for disorder, within a developmental framework. A downstream effect is described by Temple (1997) as the way one impairment can have a 'knock-on effect' (p.12) on the acquisition of other aspects of development. Applied to these findings, one could argue that input difficulties at T1 have a knock-on effect on the further development of speech output skills. However, a finer grained analysis did not find a particular aspect of input processing to be the core deficit. Also, the role of speech output skills in the development of later speech output skills was not considered (they will be explored in Chapter 9), as the analyses focused on the relative contribution of the two speech input measures.

Input skills - specific or general - might have a downstreaming effect, either between T1 and T3 or earlier on in life, whether the children display current difficulties in this area or not. Whilst there is no evidence from early development, the relative effect of speech output and speech input skills over time on the development of later speech output skills between 4 and 6 years can be examined.

Evidence thus far suggests that the speech processing system is best construed as a dynamic and interactive system, not a stable entity. Speech output skills certainly do not remain static, and even the most unintelligible participants made gains in speech production. Rather than seek an unchanging core deficit, the challenge is to find what factors – within the speech processing system and/or other language skills – are instrumental or causal in the development of these children's speech. Tracking this development has a number of important implications. First, it might give support to the operation of a 'downstream effect' where earlier speech input skills affect later speech output skills. This downstream effect may not be specific to disordered development, but be a causal skill in normal or atypical speech development. Additionally, within a disordered population, such an analysis may highlight prognostic factors in these children's speech outcome. In order to examine these potential implications, one needs to look for associations between tasks at different ages and between ages in order to examine the relationship between levels of processing, rather than differentiation or dissociation between levels. This sort of analysis of individual difference requires an understanding of the relationships that occur in normal development as well as atypical development, as discussed in the following chapter.

Chapter 9
Speech processing skills: the relationship between tasks of speech output, speech input and language ability

9.1. Introduction

In Chapter 8, patterns of speech processing profile were uncovered within the speech disordered group. As these patterns were variable across children, the analyses confirmed the heterogeneity of this population in terms of their speech processing skills. Some key speech processing patterns were identified. A speech processing profile within which deficits were confined to speech output skills was quite common, and this pattern was an indicator of better speech outcome than the alternative pattern of more pervasive difficulties throughout the speech processing system (though there were several exceptions). Analysis of word/nonword repetition profiles found that unusual patterns of performance compared to the control group were relatively rare, and the majority of the speech disordered group had profiles in line with the control group. However, children with better speech outcomes were more likely than those with persisting speech difficulties to have a stable profile in line with a normal word/nonword discrepancy pattern. The finding of instability runs contrary to an emphasis on identifying a core atypical pattern of performance.

The cognitive neuropsychology tradition builds theoretical models from patterns of dissociation in order to explicate a processing architecture (Bishop, 1997). This raises two issues in relation to the data. If dissociations (which are atypical) are relatively infrequent, such an approach will not have much clinical application for the majority of children. Second, in a developing system, patterns of atypical dissociation are unlikely to remain stable and there is increasing evidence for changing profiles of performance over time. Findings reported in Chapters 6 and 8 found that variability occurred not just between children, but over time within individuals, indicating a developing and unstable speech processing system. Identifying dissociations according to a speech processing model that is non-developmental allows 'snapshots' of a child's speech processing skills to be taken. Such snapshots can give insights into a child's speech processing skills at one time, and when compared to subsequent assessments, allow for a description of the 'unfolding' nature of the speech processing difficulty. Whilst it is argued that stable dissociations over time are not to be expected in a developing system, specifiable relationships between skills at different ages are predicted. In Chapter 8, relationships between different components of the input processing system and later speech skills were examined. This showed an overall contribution of input processing to output but failed to consistently find that one type of input skill would be specifically related to a particular speech output task. The hypotheses tested proved to be too specific and narrow, unrealistic in a developing system where skills are very likely to be interactive. Methodological considerations also make it more difficult to identify stable patterns in a longitudinal study.

This chapter seeks to explore more general hypotheses regarding the causal relationships between output, input and language skills. It is possible that one set of skills (e.g. speech input skills) may exert a causal influence on another set of skills (e.g. speech output skills). Such a causal relationship has been termed a downstreaming effect (Temple, 1997) and has important implications for characterising the nature of speech/language difficulties. With a concurrent perspective, downstreaming effects cannot be identified. As Bishop (1997) advocates, the focus must be on association, not dissociation, and interaction and change made the focal part of the investigation. As children are following their own individual path of speech development (Vihman, 1996), a longitudinal dataset is one way that this individual difference can be explored effectively.

The longitudinal design of this study presents an opportunity to examine the development of these relationships over time in both normal and atypical development. The possible downstream effect of speech input skill on the development of speech output will be explored. Since some children with speech difficulties have co-occurring input problems (e.g. Bird & Bishop, 1992; Rvachew & Jamieson, 1989), it is important to explore the relationship between these skills in both normal and atypical development. Some evidence has already been presented in Chapter 7 showing input processing difficulties are associated with persisting speech problems. Equally it is possible that there is a reciprocal relationship: the role of speech input skills in the development of speech output skills is mediated by speech output. Thus speech output skills may have a causal influence on both later speech output and speech input skills, revealing a more interactive pattern of development.

This chapter will also examine the role of language skills in the development of speech processing skills. The role of language skills, as well as speech input skills, has already been shown to be related to eventual speech outcome and the literature shows that these problems do co-occur (e.g. Lewis et al., 1989, 2000; St. Louis et al., 1992). Through regression analyses it will be possible to explore the relative contribution these skills make in speech development.

9.1.1. Research questions

1. What is the relationship between measures of speech output, speech input and language skills?
2. What is the relative contribution of speech output and speech input skills to later speech output skills (for both the speech disordered group and the control group)?
3. What is the relative contribution of speech output and speech input skills to later speech input skills (for both the speech disordered group and the control group)?
4. What is the relative contribution of language skills to later speech output skills (for both the speech disordered group and the control group)?

9.2. Results

The first part of the results section looks at the relationships between the speech input and output tasks. First, cross-sectional correlations and the longitudinal correlations are presented. With these and subsequent analyses, the control group and the speech disordered group are examined separately in order to capture relationships in normal and atypical development. A factor analysis is also reported that examined whether there were underlying factors to these tasks. Then the relative contributions of input and output skills to later input and output measures are explored through a series of multiple regressions.

Having explored relationships between input and output skills, the second part of the results section widens the analysis to include other aspects of the test battery, including language tasks, nonverbal ability and maturation, as measured by age. The relationships of these skills with output and input skills are also explored through correlations, factor analysis and multiple regressions.

9.2.1. Relationships between the speech output tasks

Relationships between speech output measures for the control group and the speech disordered group were examined. Correlations by group between all speech processing measures are reported in Tables 9.1-9.6. Relationships between the speech output measures will be discussed here (the relationship between speech input measures and between speech output measures and input measures is discussed in Section 9.2.2 and 9.2.3).

For the speech disordered group at all testing phases, the speech output tasks are very highly correlated. Even though the articulatory naming task is not matched to the other speech output tasks in the same way that the word and nonword repetition tasks are, it correlates highly with these tasks. For the control group, the speech output tasks are moderate to highly correlated, except that articulatory naming correlates weakly or non-significantly with the other speech output measures at T2.

Since the degree of correlation was so different between the two groups, Fisher's test was used to calculate whether these differences between the groups reached significance (Howell, 1982). Tables 9.7-9.9 show the z values for the correlations. Taking a cut off of +/- 1.96 (as recommended by Howell, 1982), it can be seen that the correlations of the speech disordered group were significantly higher than those of the control group for all the speech output tasks, except between nonword repetition and LF word repetition at T2 and between LF nonword repetition and Naming at T3. No score was calculated when there was a significant correlation for one group but not the other, and is marked 'N/A' in the tables.

The difference in degree of relationship between the speech output tasks between groups could be due to a restricted range of scores in the control group. Certainly, inspection of distributions reveals that some ceiling effects were apparent on the word and nonword repetition tasks at T2. However, this cannot account for all the differences between the groups because, for example, ceiling effects were not noted on the LF repetition tasks.

Table 9.1.

Correlations of the speech output and speech input tasks: T1 (Speech disordered group)

	ABX	AD: Pic	AD:S/D	WRep	NWRep	AName
ABX	-					
AD: Pic	.14	-				
AD: S/D	.31*	.38*	-			
WRep	.33*	.49**	.12	-		
NWRep	.31*	.56**	.12	.94**	-	
AName	.27	.51**	.20	.81**	.82**	-

* $p<.01$
** $p<.001$
Key: ABX = AD: ABX; AD: Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); Aname = Articulatory naming (pcc)

Table 9.2.
Correlations of the speech output and speech input tasks: T2 (Speech disordered group)

	ABX	AD:Pic	AD: S/D	WRep	NWRep	LFWRep	LFNWRep	AName
ABX	-							
AD:Pic	.55**	-						
AD: S/D	.62**	.39*	-					
WRep	.43*	.44*	.32	-				
NWRep	.48**	.45*	.39*	.95**	-			
LFWRep	.51**	.53**	.31*	.88**	.87**	-		
LFNWRep	.48**	.47**	.30*	.88**	.88**	.94**	-	
AName	.47**	.41*	.33*	.89**	.91**	.87**	.87**	-

* $p<.01$
** $p<.001$
Key: ABX = AD: ABX; AD:Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc)

Table 9.3.

Correlations of the speech output and speech input tasks: T3 (Speech disordered group)

	ABX	AD:Pic	LFWRep	LFNWRep	AName
ABX	-				
AD:Pic	.38*	-			
LFWRep	.45*	.14	-		
LFNWRep	.46**	.13	.88**	-	
AName	.22	.15	.78**	.68**	-

* $p<.01$
** $p<.001$
Key: ABX = AD: ABX; AD: Pic = AD: picture; LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc)

Table 9.4.
Correlations of the speech output and speech input tasks: T1 (Control group)

	ABX	AD:Pic	AD: S/D	WRep	NWRep	AName
ABX	-					
AD:Pic	.45*	-				
AD: S/D	.52**	.41*	-			
WRep	.34*	.60**	.37*	-		
NWRep	.39*	.62**	.31*	.75**	-	
Aname	.32*	.57**	.38*	.60**	.51**	-

* $p<.01$
** $p<.001$
Key: ABX = AD: ABX; AD:Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); Aname = Articulatory naming (pcc)

Table 9.5.
Correlations of the speech output and speech input tasks: T2 (Control group)

	ABX	AD:Pic	AD: S/D	WRep	NWRep	LFWRep	LFNWRep	AName
ABX	-							
AD:Pic	.41*	-						
AD: S/D	.43*	.45*	-					
WRep	.39*	.40*	.31*	-				
NWRep	.39*	.58**	.43*	.43*	-			
LFWRep	.32*	.42*	.35*	.43*	.75**	-		
LFNWRep	.47**	.46**	.45*	.52**	.72**	.64**	-	
Aname	.18	.17	.20	.14	.31*	.31*	.18	-

* p<.01
** p<.001
Key: ABX = AD: ABX; AD:Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc)

Table 9.6.
Correlations of the speech output and speech input tasks: T3 (Control group)

	ABX	AD:Pic	LFWRep	LFNWRep	AName
ABX	-				
AD:Pic	.31*	-			
LFWRep	.54**	.32*	-		
LFNWRep	.33*	.67**	.61**	-	
AName	.32*	.37*	.53**	.56**	-

* $p<.01$
** $p<.001$

Key: ABX = AD: ABX; AD: Pic = AD: picture; LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc)

Table 9.7.
Fisher's z-score showing differences between the correlations of the Speech disordered group and the Control group: T1

	WRep1	NWRep1	AName1
WRep1	-		
NWRep1	3.64	-	
AName1	2.07	2.83	-

Key: WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); Aname = Articulatory naming (pcc)

Table 9.8.
Fisher's z-score showing differences between the correlations of the Speech disordered group and the Control group: T2

	WRep2	NWRep2	LFWRep2	LFNWRep2	AName2
WRep2	-				
NWRep2	6.53	-			
LFWRep2	4.36	1.7	-		
LFNWRep2	3.81	2.23	4.67	-	
AName2	N/A	5.85	N/A	N/A	-

Key: WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc)

Table 9.9.
Fisher's z-score showing differences between the correlations of the Speech disordered group and the Control group: T3

	LFWRep3	LFNWRep3	AName3
LFWRep3	-		
LFNWRep3	3.03	-	
AName3	2.07	1.22	-

Key: LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc)

9.2.2. Relationships between the speech input tasks

Correlations between the speech input tasks are reported in Tables 9.1-9.6 (*d'* scores were used in all calculations). The speech input tasks were moderately to highly correlated with each other for both groups of children. The degree of correlation was similar for each group, unlike the speech output tasks.

9.2.3. Relationships between speech output and speech input tasks

Overall, there were moderate to strong correlations between measures of speech output and speech input. However, there were exceptions. For the speech disordered group, at T1, the AD: same/different task did not correlate with the speech output tasks. The AD: ABX task did not correlate significantly with articulatory naming. At T3, there was also no correlation between AD: ABX and articulatory naming and, the AD: picture task was no longer significantly correlated with any speech output tasks. For the control group, there were significant correlations between speech output and input tasks with the exception of articulatory naming at T2 which had only weak correlations with both other speech input and speech output tasks.

A Principal Component factor analysis with Varimax rotation was conducted to explore whether the speech output and speech input tasks loaded on separate output and input factors. Z-scores were calculated for the speech disordered and the control group separately and two factor analyses were run, one for each group. Due to the relatively small number of cases and the issues of task sensitivity, the factor analyses included measures collapsed across testing phases. Measures of word repetition, nonword repetition, articulatory naming, AD: ABX and AD: picture task were collapsed over time. Composites of the original and extension repetition tasks were created in order to use one measure across time (word/nonword was still separated). As AD: same/different task was only measured at T1 and T2, this was excluded from the analysis. For both groups, only one factor was extracted. The Eigen value for the speech disordered group was 3.18 and, for the control group, 2.47. Loadings for the factor are reported in Table 9.10 for each group. The factor, which could be termed a speech processing factor, accounted for 63.65% of the variance for the speech disordered group, and 49.36% for the control group. For the speech disordered group, the two speech input measures recorded lower loading values than the speech output task, but were not sufficiently differentiable to load on different factors. For the control group, the input measures also had lower loading values, but there was less of a difference between input and output. Articulatory naming had a very low loading value of .33 and reflects the lack of correlation this measure showed with other variables.

Table 9.10.
Orthogonally rotated factor matrices for the speech processing measures for the Speech disordered group and the Control group

	Loadings of the speech processing factor	
Measures	Speech disordered group	Control group
Word repetition	.94	.83
Nonword repetition	.94	.86
Articulatory naming	.88	.33
AD: ABX	.58	.62
AD: picture	.56	.75

9.2.4. Developmental relationship between speech input and speech output

Correlations were calculated of measures between T1 and T2, T1 and T3 and T2 and T3 for each group. These showed a general pattern of relationship between speech input and speech output over time and are reported in Tables 9.11-9.16.

Table 9.11.
Correlations of the speech output and speech input tasks: T1-T2 (Speech disordered group)

	ABX1	AD: Pic1	AD: S/D1	WRep1	NWRep1	AName1
ABX2	.45*	.42*	.42*	.39*	.43*	.42*
AD: Pic2	.19	.48**	.07	.40*	.45*	.40*
AD: S/D2	.21	.40*	.45*	.13	.15	.17
WRep2	.30*	.48**	.15	.73**	.72**	.71**
NWRep2	.37*	.48**	.23	.73**	.74**	.73**
LFWRep2	.21	.52**	.16	.74**	.79**	.75**
LFNWRep2	.31*	.50**	.14	.72**	.76**	.74**
AName2	.26	.46**	.17	.72**	.76**	.75**

* $p<.01$
** $p<.001$

Key: ABX = AD: ABX; AD: Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc). 1 corresponds to T1; 2 corresponds to T2.

Table 9.12.

Correlations of the speech output and speech input tasks: T2-T3 (Speech disordered group)

	ABX2	AD: Pic2	AD: S/D2	WRep2	NWRep2	LFWRep2	LFNWRep2	AName2
ABX3	.43*	.39*	.16	.39*	.39*	.46**	.42*	.37*
AD: Pic3	.09	.23	.11	.14	.14	.12	.16	.09
LFWRep3	.69**	.62**	.50**	.74**	.74**	.77**	.74**	.73**
LFNWRep3	.61**	.44*	.40*	.70**	.70**	.80**	.76**	.71**
AName3	.47**	.67**	.39*	.65**	.64**	.65**	.59**	.63**

* $p<.01$
** $p<.001$

Key: ABX = AD: ABX; AD:Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc). 2 corresponds to T2; 3 corresponds to T3.

Table 9.13.
Correlations of the speech output and speech input tasks: T1-T3 (Speech disordered group)

	ABX1	AD: Pic1	AD: S/D1	WRep1	NWRep1	AName1
ABX3	.27	.31*	.11	.51**	.49**	.43*
AD:Pic3	.22	.31*	.04	.20	.19	.19
LFWRep3	.31*	.49**	.27	.57**	.66**	.62**
LFNWRep3	.38*	.44*	.21	.57**	.65**	.67**
AName3	.19	.43*	.09	.45*	.51**	.60**

* $p<.01$
** $p<.001$
Key: ABX = AD: ABX; AD: Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc). 1 corresponds to T1; 3 corresponds to T3.

Table 9.14.

Correlations of the speech output and speech input tasks: T1-T2 (Control group)

	ABX1	AD: Pic1	AD: S/D1	WRep1	NWRep1	AName1
ABX2	.55**	.48**	.33*	.43*	.53**	.31*
AD: Pic2	.32*	.68**	.39*	.55**	.46**	.48**
AD: S/D2	.55**	.33*	.39*	.30*	.36*	.32*
WRep2	.28	.63**	.41*	.43*	.40*	.41*
NWRep2	.43*	.56**	.57**	.63**	.55*	.66**
LFWRep2	.50**	.61**	.49**	.40*	.57**	.51**
LFNWRep2	.44*	.53**	.46**	.58**	.48**	.64**
AName2	.25	.24	.36*	.31*	.27	.07

* $p<.01$
** $p<.001$
Key: ABX = AD: ABX; AD: Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc). 1 corresponds to T1; 2 corresponds to T2.

Table 9.15.
Correlations of the speech output and speech input tasks: T2-T3 (Control group)

	ABX2	AD: Pic2	AD: S/D2	WRep2	NWRep2	LFWRep2	LFNWRep2	AName2
ABX3	.52**	.58**	.39*	.32*	.34*	.28	.45*	.007
AD:Pic3	.25	.25	.22	.21	.53**	.45*	.65**	-.02
LFWRep3	.46**	.60**	.34*	.52**	.65**	.45*	.61**	.27
LFNWRep3	.46**	.47**	.24	.33*	.65**	.58**	.70**	.19
AName3	.35*	.25	.26	.47**	.41**	.37*	.48**	.12

* p<.01
** p<.001
Key: ABX = AD: ABX; AD: Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc). 2 corresponds to T2; 3 corresponds to T3.

Table 9.16.
Correlations of the speech output and speech input tasks: T1-T3 (Control group)

	ABX1	AD: Pic1	AD: S/D1	WRep1	NWRep1	AName1
ABX3	.38*	.36*	.08	.36*	.34*	.20
AD: Pic3	.36*	.20	.25	.36*	.28	.55**
LFWRep3	.28	.65**	.46**	.65**	.53**	.60**
LFNWRep3	.38*	.40*	.55**	.53**	.39**	.52**
AName3	.23	.29	.21	.32*	.31*	.24

* $p<.01$
** $p<.001$

Key: ABX = AD: ABX; AD: Pic = AD: picture; AD: S/D = AD: same/different; WRep = Word repetition (pcc); NWRep = Nonword repetition (pcc); LFWRep = LF word repetition (pcc); LFNWRep = LF NW repetition (pcc); Aname = Articulatory naming (pcc). 1 corresponds to T1; 3 corresponds to T3.

9.2.5. Predicting speech output and speech input performance

Concurrent and longitudinal correlations have shown that relationships exist between some measures of speech output and input processing. The longitudinal nature of the study allows further exploration of these relationships. In order to examine the longitudinal relationships between speech output and speech input in both groups of children whilst taking account of shared variance, a series of hierarchical multiple regressions was conducted.

9.2.5.*1*. Procedure for hierarchical regression

Composite measures of speech output and speech input at T1 and T2 were formed. The speech output composite consisted of word and nonword repetition tasks. The articulatory naming task was excluded as this did not correlate with other speech tasks at T2 (control group) or with later articulatory naming (again, control group). The speech input composite included the 3 tasks used at T1 and T2, with *d'* scores used.

The composite measures were formed using z- scores which had been calculated according to each group's mean and SD for each test. When interpreting the developmental course of speech processing skills in the disordered group, one would therefore be observing the performance of these skills within this population and not relative to normal development.

The composites of speech output and speech input were entered into a multiple regression as predictor variables in order to assess their relative contribution to measures of speech input and speech output taken at later testing phases. These were measures of word repetition, nonword repetition, AD: same/different, AD: picture and AD: ABX (calculated, again, as z-scores). At T2, the word repetition and nonword repetition were composites of the 2 versions, i.e. the original and low frequency tasks.

Speech output and speech input measured at T1 were entered into regressions to assess prediction of T2 and T3 individual measures of speech input and speech output. Speech output and speech input measured at T2 were entered into regressions to assess prediction of T3 individual measures of speech input and speech output. Results are reported in Tables 9.17-9.22 (dependent variable is marked as DV).

9.2.5.2. Predicting speech output

Speech disordered group

For the speech disordered group, speech output measured at T1 was highly predictive of word and nonword repetition at both T2 and T3. Overall, speech output and speech input at T1 accounted for 64% of the variance (Adjusted R^2) in T2 word repetition, and 63% of the variance in T2 nonword repetition. For the longer term prediction between T1 and T3, the speech processing skills accounted for 43% of the variance for both word and nonword repetition. Larger amounts of variance were accounted for by these skills measured at T2, predicting speech output skills a year later: they accounted for 74% of the variance in word repetition, and 62% of the variance in nonword repetition.

The composite speech input measure at T1 was significant when entered at the first step, but it offered no unique variance in the equation as, once the autoregressive effect of speech output was controlled for, it was not significantly predictive. Conversely, the speech output composite predicted significant unique variance, after controlling for the effects of speech input. Its degree of prediction was greatest between the shorter time period: T1 and T2, and less, though still highly significant, between T1 and T3. There were no notable differences in predictors depending on whether the task involved word or nonword repetition.

A different pattern of prediction was noted between measures taken at T2 and speech skills at T3. Speech output skills were still highly predictive of later speech output skills and contributed unique variance after controlling for speech input skills. However, the role of speech input skills was now much larger. After controlling for the autoregressor, speech output, speech input contributed significant unique variance in both word and nonword repetition. For word repetition, speech input contributed an additional 14% of variance; for nonword repetition, the effect was much smaller, though still significant, with 4% of unique variance.

Control group

Compared to the speech disordered group, speech processing skills accounted for less overall variance in later speech output skills in the control group. On average, these skills accounted for approximately 35% of the variance. Speech output measured at T1 was predictive of word repetition at both T2 and T3, once speech input skills had been controlled for. Speech output was predictive of T2 nonword repetition, but not T3 nonword repetition, after controlling for speech input. Speech input was also uniquely predictive of the other, later repetition skills, after controlling for the autoregressor, speech output.

Both speech output and speech input at T1 were roughly equally predictive of repetition skills a year later, at T2. For word repetition, input and output contribute fairly equally, respectively, 9% and 12% of unique variance when each were entered at the last step; for nonword repetition, speech output contributes more unique variance, with 17% at the last step, compared to speech input's 8%. For the longer term prediction of T3 word repetition skills, both output and input are again similar in the amounts of significant unique variance predicted (9% output, 11% input). For nonword repetition at T3, however, speech output at T1 offers no significant unique variance, whilst speech input contributes 18%.

Measures taken at T2 to predict T3 repetition performance show a similar pattern to that between T1 and T2, with speech output and speech input both contributing unique variance.

9.2.5.3. Predicting speech input

Speech disordered group

For speech input, there is a less cohesive pattern of predictors. Less overall variance was accounted for in speech input skills by earlier speech processing measures, and sometimes the amount of variance was negligible. T1 speech processing measures accounted for overall variance ranging from 19-38% in the three speech input measures a year later, at T2. These measures at T1 accounted for only 4% of the variance in AD: picture task two years later, at T3. These measures at T2 accounted for no variance at T3 for the AD: picture task. However, speech processing measures at T1 and at T2 accounted for larger amounts of variance at T3 in predicting the AD: ABX task (28% for T1→T3; 18% for T2→T3). Compared to the prediction of speech output skills, earlier speech processing measures predicted much less of the variance in later speech input skills.

The speech output composite does, on occasion, uniquely predict variance in speech input skills. Speech output measured at T1 predicts unique variance in AD: picture task at T2 and AD: ABX task at T3. The better one's speech skills at T1, the better one's input skills later on.

A diagram of these relationships is shown in Figure 9.1. One-way arrows between boxes represent a significant longitudinal relationship between skills where unique variance was predicted. Two-way arrows show significant concurrent relationships between speech output and speech input.

Control group

The amount of overall variance accounted for by the speech processing measures in later speech input skills was variable. T1 speech processing measures accounted for between 21-30% of variance in the speech input measures at T2. Less overall variance was accounted for at T1 in the longer term prediction of T3 AD: picture task (12%) and ABX (6%). Measures at T2 accounted for 22% of the variance in AD: picture task at T3, and 29% in AD: ABX at T3.

Speech input skills are, in the main, predictive of later speech input skills. Once the autoregressor, speech input, is controlled for, speech output offers no unique prediction except in one case: T2 speech output does contribute significant unique variance in AD: picture task (10%) at T3 (though this task was at ceiling at T3, so the result is questionable). A summary of these relationships for the control group is illustrated in Figure 9.2. One-way arrows between boxes represent a significant longitudinal relationship between skills where unique variance was predicted. Two-way arrows show significant concurrent relationships between speech output and speech input.

Table 9.17.
Hierarchical multiple regression of T1 measures predicting speech output measures at T2

	Variables entered	Speech disordered					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: WRep										
Step 1	Output	.66	.65	.66	80.21	<.001	.28	.26	.28	16.73	<.001
Step 2	Input	.66	.64	.001	.18	ns	.37	.34	.09	6.42	<.05
Step 1	Input	.17	.15	.17	8.55	<.01	.25	.23	.25	14.57	<.001
Step 2	Output	.66	.64	.49	58.55	<.001	.37	.34	.12	8.25	<.01
	DV: NWRep										
Step 1	Output	.63	.63	.63	72.30	<.001	.34	.32	.34	22.56	<.001
Step 2	Input	.64	.63	.01	1.33	ns	.42	.39	.08	5.77	<.05
Step 1	Input	.22	.20	.22	11.60	<.001	.25	.23	.25	14.53	<.001
Step 2	Output	.64	.63	.43	49.26	<.001	.42	.39	.17	12.46	<.001

Table 9.18.
Hierarchical multiple regression of T1 measures predicting speech output measures at T3

	Variables entered	Speech disordered					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: WRep										
Step 1	Output	.41	.39	.41	28.66	<.001	.27	.25	.27	15.0	<.001
Step 2	Input	.46	.43	.05	3.82	.06	.38	.35	.11	7.34	<.01
Step 1	Input	.25	.23	.25	13.67	<.001	.29	.27	.29	16.71	<.001
Step 2	Output	.46	.43	.21	15.88	<.001	.38	.35	.09	5.94	<.05
	DV: NWRep										
Step 1	Output	.41	.40	.41	29.38	<.001	.15	.13	.15	7.20	<.01
Step 2	Input	.45	.43	.04	2.98	.09	.33	.30	.18	10.94	<.005
Step 1	Input	.23	.21	.23	12.25	<.001	.31	.29	.31	18.50	<.001
Step 2	Output	.45	.43	.23	16.86	<.001	.33	.30	.02	1.26	ns

Table 9.19.

Hierarchical multiple regression of T2 measures predicting speech output measures at T3

	Variables entered	Speech disordered					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: WRep										
Step 1	Output	.61	.60	.61	69.6	<.001	.26	.25	.26	14.70	<.001
Step 2	Input	.75	.74	.14	24.04	<.001	.41	.38	.14	9.62	<.005
Step 1	Input	.54	.53	.54	51.77	<.001	.32	.30	.32	18.88	<.001
Step 2	Output	.75	.74	.21	36.57	<.001	.41	.38	.09	6.16	<.05
	DV: NWRep										
Step 1	Output	.59	.58	.59	65.59	<.001	.28	.26	.28	15.55	<.001
Step 2	Input	.64	.62	.04	5.09	<.05	.38	.35	.11	7.08	<.01
Step 1	Input	.34	.33	.34	23.45	<.001	.27	.26	.27	15.44	<.001
Step 2	Output	.64	.62	.29	35.31	<.001	.38	.35	.11	7.17	<.05

Table 9.20.

Hierarchical multiple regression of T1 measures predicting speech input measures at T2

	Variables entered	Speech disordered					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: AD: Pic										
Step 1	Output	.22	.21	.22	12.06	<.001	.19	.18	.19	10.60	<.005
Step 2	Input	.25	.22	.03	1.60	ns	.33	.30	.13	8.55	<.005
Step 1	Input	.41	.12	.14	6.70	<.05	.27	.25	.27	16.03	<.001
Step 2	Output	.25	.22	.12	6.28	<.05	.33	.30	.06	3.89	.06
	DV: ABX										
Step 1	Output	.20	.19	.20	10.74	<.005	.16	.15	.16	8.62	<.005
Step 2	Input	.41	.38	.21	14.63	<.001	.27	.24	.11	6.30	<.05
Step 1	Input	.38	.36	.38	25.56	<.001	.22	.20	.22	12.25	<.001
Step 2	Output	.42	.38	.04	2.43	ns	.27	.24	.05	3.12	.08
	DV: AD										
Step 1	Output	.03	.01	.03	1.40	ns	.03	.01	.03	1.49	ns
Step 2	Input	.23	.19	.20	10.63	<.005	.24	.21	.21	11.10	<.001
Step 1	Input	.23	.21	.23	12.49	<.001	.24	.23	.24	14.11	<.001
Step 2	Output	.23	.19	.00	.13	ns	.24	.21	.00	.05	ns

Table 9.21.

Hierarchical multiple regression of T1 measures predicting speech input measures at T3

	Variables entered	Speech disordered					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: AD: Pic										
Step 1	Output	.02	-.00	.02	.95	ns	.07	.05	.07	3.22	.08
Step 2	Input	.09	.04	.07	2.97	ns	.16	.12	.09	4.24	**<.05**
Step 1	Input	.09	.07	.09	4.06	**<.05**	.15	.13	.15	7.31	**<.01**
Step 2	Output	.09	.04	.00	.00	ns	.16	.12	.01	.49	ns
	DV: ABX										
Step 1	Output	.28	.26	.28	15.58	**<.001**	.09	.06	.09	3.79	.06
Step 2	Input	.31	.28	.04	2.28	ns	.10	.06	.02	.72	ns
Step 1	Input	.19	.17	.19	9.29	**<.005**	.06	.04	.08	2.67	ns
Step 2	Output	.31	.28	.13	7.56	**<.01**	.10	.06	.04	1.76	ns

Table 9.22.

Hierarchical multiple regression of T2 measures predicting speech input measures at T3

	Variables entered	Speech disordered					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
	DV: AD: Pic										
Step 1	Output	.02	.00	.02	.99	ns	.21	.19	.21	10.74	**<.005**
Step 2	Input	.03	-.01	.01	.53	ns	.25	.22	.05	2.52	ns
Step 1	Input	.03	.01	.03	1.33	ns	.15	.13	.15	7.40	**<.01**
Step 2	Output	.03	-.01	.00	.20	ns	.25	.22	.10	5.45	**<.05**
	DV: ABX										
Step 1	Output	.19	.17	.19	9.99	**<.005**	.12	.10	.11	5.39	**<.05**
Step 2	Input	.22	.18	.03	1.71	ns	.33	.29	.21	12.12	**<.001**
Step 1	Input	.14	.12	.14	7.34	**<.01**	.32	.30	.32	18.40	**<.001**
Step 2	Output	.22	.18	.07	4.02	.06	.33	.29	.01	.73	ns

Figure 9.1
Summary of unique predictors in multiple regression analyses: Relationships between components of the speech processing system (Speech disordered group)

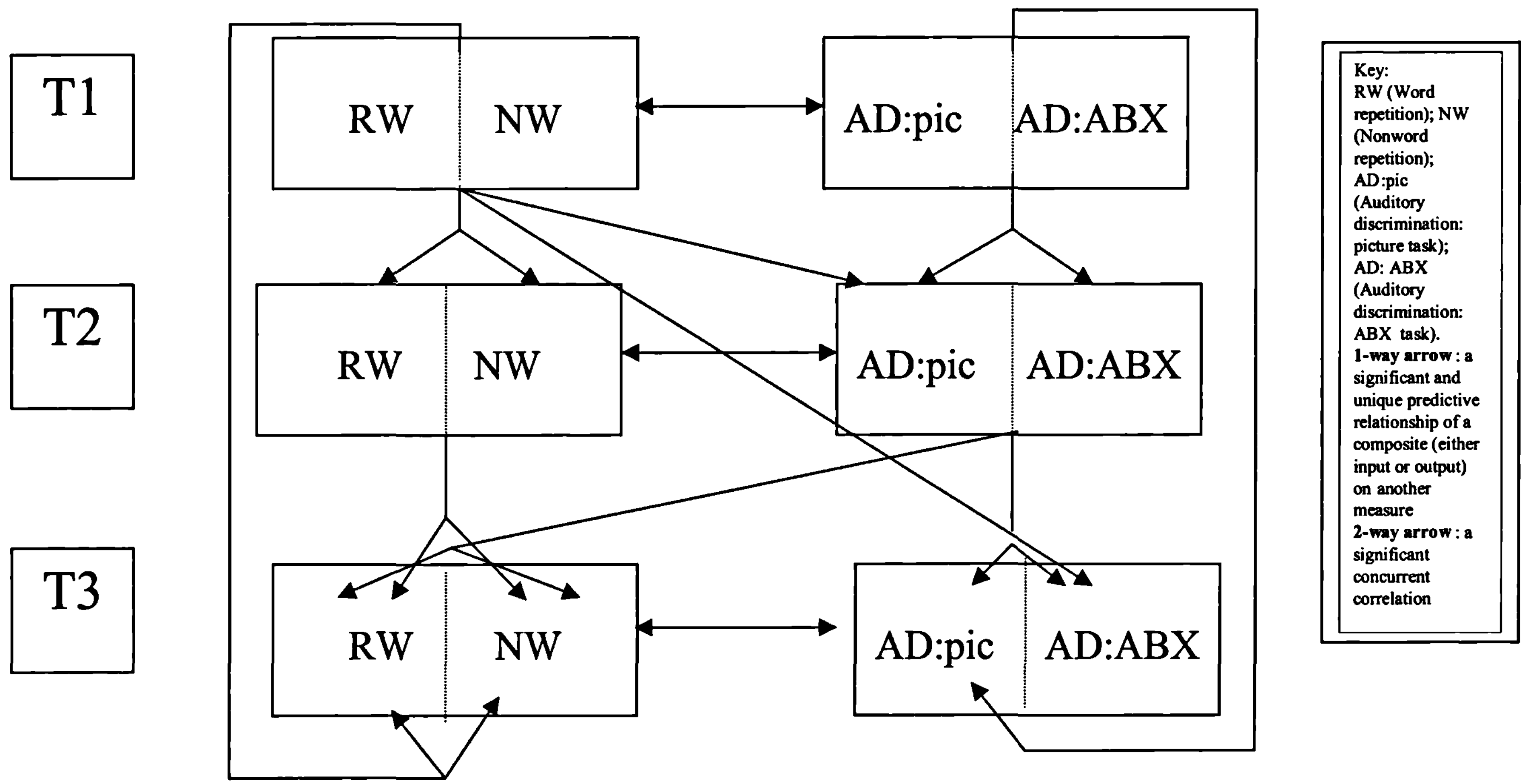
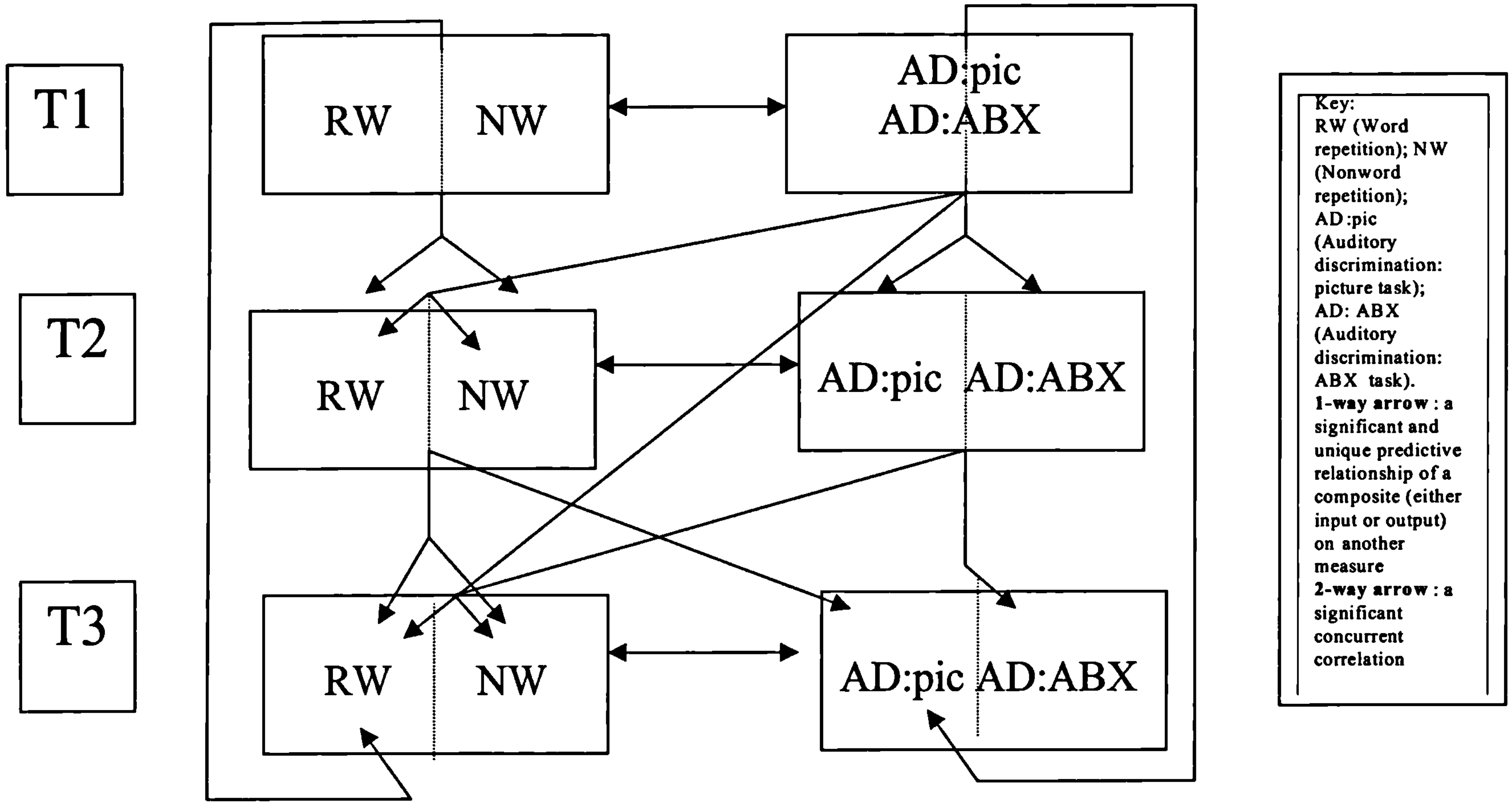


Figure 9.2.
Summary of unique predictors in multiple regression analyses: Relationships between components of the speech processing system (Control group)



9.2.6. Relationships between speech processing and language skill

In order to examine the relationship between the speech processing system and language skills, concurrent correlations were calculated. Given the number of measures, composite scores of speech output and speech input were used to examine general associations between speech processing and specific language measures at each testing phase, as reported in Tables 9.23-9.25 for the speech disordered group, and Tables 9.27-9.29 for the control group. Many relationships between speech processing and language measures are evident.

Composite scores were used as follows:

Speech output:	T1: Wpcc/NWRep/Namingpcc; T2: Wpcc/NWRep/ Namingpcc/ LFWpcc/LFNWRep; T3: Namingpcc/ LFWpcc/LFNWRep
Speech input:	T1: AD: Pic/ AD: ABX/ AD: S/D; T2: AD: Pic/ AD: ABX/ AD: S/D; T3: AD: Pic II/ AD: ABX (all *d'* scores)

Correlations of longitudinal relationships were also calculated (Tables 9.26 and 9.30), this time using composites of expressive and receptive language as well, as follows:

Expressive language:	T1, T2, T3: Bus Story Information/MLU, RAPT Information/grammar, Naming
Receptive language:	T1, T2, T3: BPVS, TROG.

For the speech disordered group, correlations are high between T1 language measures and T2 speech processing composites. There are also significant correlations between T1 language measures and T3 speech processing composites. The longer term correlation between T1 speech input and T3 receptive language was not significant, but all others were moderately significant between these testing phases.

For the control group, there is a very even pattern of relationships between speech processing and language measures, with earlier language composites showing highly significant relationships with later speech processing measures.

A Principal Component factor analysis with Varimax rotation was conducted to explore whether the speech processing and language measures loaded on separate factors or a combined factor. Z-scores were calculated for the speech disordered and the control group separately and two factor analyses were run, one for each group. Due to the relatively small number of cases and the issues of task sensitivity, the factor analyses included measures collapsed across testing phases. Composites of the original and extension repetition tasks were used in order to have one measure across time (word/nonword was still separated). As AD: same/different task was only measured at T1 and T2, this was excluded from the analysis. For both groups, two factors were extracted. Loadings for these are reported in Tables 9.31 and 9.32. The Eigen value for the speech disordered group was 5.52 and, for the control group, 5.48. For the speech disordered group, all the tests accounted for 46% of the variance and for the control group 45.6% of the variance. For the speech disordered group, speech processing measures load on one factor (a speech processing factor), accounting for 14.3% of the variance, and language measures on another, slightly smaller factor (a language factor) accounting for 8.3% of the variance. There is one exception: RAPT (grammar score) has more loading on the speech processing factor.

The factors look different for the control group. The larger factor, accounting for 10.2% of the variance, contains both speech processing and language measures and includes 10/12 of all the measures. The second slightly smaller factor, with 8.2% of the variance, contains the RAPT only (grammar and information score).

Table 9.23.
Correlations of composites of speech output, speech input with expressive and receptive language tasks: T1 (Speech disordered group)

	Output	Input	Bus (I)	Bus (MLU)	RAPT(I)	RAPT (G)	Name	BPVS	TROG
Output	-								
Input	.50**	-							
Bus (I)	.43*	.35*	-						
Bus (MLU)	.43*	.28	.82**	-					
RAPT(I)	.28	.42*	.51**	.33*	-				
RAPT (G)	.60**	.47**	.66**	.67**	.57**	-			
Name	.32*	.29	.47**	.30*	.11	.39*	-		
BPVS	.22	.50**	.44*	.36*	.31*	.52**	.61**		-
TROG	.46**	.44*	.55**	.56**	.36*	.57**	.39*	.59**	
-									

* p<.01
** p<.001

Table 9.24.
Correlations of composites of speech output, speech input with expressive and receptive language tasks: T2 (Speech disordered group)

	Output	Input	Bus (I)	Bus (MLU)	RAPT(I)	RAPT (G)	Name	BPVS	TROG
Output	-								
Input	.53**	-							
Bus (I)	.29*	.42*	-						
Bus (MLU)	.24	.37*	.86**	-					
RAPT(I)	.41*	.43*	.53**	.40*	-				
RAPT (G)	.61**	.45*	.53**	.52**	.59**	-			
Name	.22	.30*	.55*	.42*	.41*	.36*	-		
BPVS	.26	.42*	.57**	.47**	.46**	.41*	.53**	-	
TROG	.33	.45**	.67**	.68**	.43*	.55**	.60**	.55**	-

* p<.01
** p<.001

Table 9.25.
Correlations of composites of speech output, speech input with expressive and receptive language tasks: T3 (Speech disordered group)

	Output	Input	Bus (I)	Bus (MLU)	RAPT(I)	RAPT (G)	Name	BPVS	TROG
Output	-								
Input	.34*	-							
Bus (I)	.37*	.25	-						
Bus (MLU)	.41*	.22	.55**	-					
RAPT(I)	.43*	.28	.36*	.23	-				
RAPT (G)	.59**	.27	.35*	.31*	.44*	-			
Name	.25	.25	.49**	.38*	.40*	.16	-		
BPVS	.29*	.20	.47**	.48**	.42*	.14	.65**	-	
TROG	.40*	.25	.48**	.33*	.31*	.45*	.52*	.52**	-

* p<.01
** p<.001

Table 9.26.
Longitudinal correlations of composites of speech output, speech input, expressive and receptive language tasks (Speech disordered group)

	Output1	Input1	Expres1	Recep1	Output2	Input2	Expres2	Recep2
Output2	.80**	.46**	.53**	.43**	-	-	-	-
Input2	.42**	.60**	.42**	.45**	-	-	-	-
Expres2	.58**	.44*	.77**	.60**	-	-	-	-
Recep2	.39**	.46**	.73**	.77**	-	-	-	-
Output3	.65**	.48**	.50**	.42**	.79**	.71**	.61**	.37*
Input3	.45**	.50**	.36*	.20	.35*	.34*	.37*	.14
Expres3	.37*	.31*	.72**	.52**	.41**	.51**	.81**	.70**
Recep3	.28	.34*	.66**	.71**	.30*	.51**	.67**	.75**

* $p<.01$
** $p<.001$

Table 9.27.
Correlations of composites of speech output, speech input with expressive and receptive language tasks: T1 (Control group)

	Output	Input	Bus (I)	Bus (MLU)	RAPT(I)	RAPT (G)	Name	BPVS	TROG
Output	-								
Input	.52**	-							
Bus (I)	.34*	.43*	-						
Bus (MLU)	.19	.44*	.68**	-					
RAPT(I)	.42*	.42*	.53**	.36*	-				
RAPT (G)	.34*	.49**	.43*	.32*	.62**	-			
Name	.28	.52**	.57**	.45*	.46**	.51**	-		
BPVS	.25	.64**	.57**	.50**	.33*	.36*	.68**	-	
TROG	.45*	.67**	.64**	.53**	.57**	.54**	.62**	.72**	-

* p<.01
** p<.001

Table 9.28.
Correlations of composites of speech output, speech input with expressive and receptive language tasks: T2 (Control group)

	Output	Input	Bus (I)	Bus (MLU)	RAPT(I)	RAPT (G)	Name	BPVS	TROG
Output	-								
Input	.60**	-							
Bus (I)	.45*	.49**	-						
Bus (MLU)	.32*	.54**	.71**	-					
RAPT(I)	.43*	.52**	.52**	.41*	-				
RAPT (G)	.33*	.19	.28	.25	.58**	-			
Name	.22	.37*	.54**	.54**	.36**	.18	-		
BPVS	.32*	.50**	.70**	.63**	.38*	.32*	.71**	-	
TROG	.30*	.57**	.58**	.52**	.32*	.17	.56**	.74	-

* p<.01
** p<.001

Table 9.29.
Correlations of composites of speech output, speech input with expressive and receptive language tasks: T3 (Control group)

	Output	Input	Bus (I)	Bus (MLU)	RAPT(I)	RAPT (G)	Name	BPVS	TROG
Output	-								
Input	.60**	-							
Bus (I)	.50**	.54**	-						
Bus (MLU)	.21	.32*	.50**	-					
RAPT(I)	-.09	.06	.29	.17	-				
RAPT (G)	.16	.20	.17	.33*	.43*	-			
Name	.52**	.42*	.66**	.33*	.17	.19	-		
BPVS	.56**	.39*	.70**	.36*	.05	.27	.75*	-	
TROG	.50**	.52**	.67**	.54**	.07	.42*	.58**	.76**	-

* p<.01
** p<.001

Table 9.30.
Longitudinal correlations of composites of speech output, speech input, expressive and receptive language tasks (Control group)

	Output1	Input1	Expres1	Recep1	Output2	Input2	Expres2	Recep2
Output2	.93**	.52**	.39**	.37*	-	-	-	-
Input2	.62**	.71**	.64**	.52**	-	-	-	-
Expres2	.46**	.54**	.76**	.70**	-	-	-	-
Recep2	.45**	.62**	.82**	.86**	-	-	-	-
Output3	.67**	.60**	.53**	.60**	.68**	.64**	.59**	.61**
Input3	.34*	.41**	.52**	.44**	.31*	.58**	.49**	.53**
Expres3	.29	.47**	.76**	.67**	.23	.52**	.68**	.72**
Recep3	.38*	.65**	.76**	.88**	.34*	.58**	.73**	.83*

* $p<.01$
** $p<.001$

Table 9.31.
Orthogonally rotated factor matrices for the speech processing and language measures for the Speech disordered group

Measures	Factor 1	Factor 2
Word repetition	**.93**	.17
Nonword repetition	**.92**	.17
Articulatory naming	**.89**	.11
RAPT (grammar score)	**.62**	.47
AD: ABX	**.45**	.30
AD: picture	**.43**	.27
Bus Story (information score)	.22	**.81**
BPVS	.13	**.79**
TROG	.28	**.74**
Naming	.13	**.74**
Bus Story (MLU score)	.23	**.72**
RAPT (information score)	.39	**.51**

Table 9.32.
Orthogonally rotated factor matrices for the speech processing and language measures for the Control group

Measures	Factor 1	Factor 2
BPVS	**.79**	.26
Nonword repetition	**.76**	
Word repetition	**.76**	.14
Naming	**.71**	.26
TROG	**.71**	.38
Bus Story (information score)	**.68**	.46
AD: picture	**.66**	
Bus Story (MLU score)	**.54**	.46
AD: ABX	**.51**	.23
Articulatory naming	**.46**	-.44
RAPT (information score)	.21	**.81**
RAPT (grammar score)	.30	**.69**

9.2.7. Relative contribution of speech processing skills and language skills to speech output

Speech input processing plays an important role in children's speech development. However, the analyses reported so far in this chapter have not included the role of language skills. Language skill as well as speech input skill was highlighted as an important factor in speech outcome (see Chapter 7). Whether language skills play a unique role in the development of speech skills will now be explored.

The following analysis therefore explores which skills measured at T1 and at T2 best predict speech performance at ages 5.7 and 6.7. As this analysis brings together a range of possible predictive factors, the effects of age and nonverbal ability are also considered and controlled for. This will allow examination of the relative roles of speech processing and language skills over and above effects due to maturation and nonverbal skills. Participants were reassessed at approximately 12 months after T1 and T2. As some fluctuation in timing occurred, the relevant age was entered for each regression (i.e. age at T1 or age at T2).

Specifically, the following questions were posed:

1. after controlling for speech, nonverbal ability and age, does language performance or input skills at T1 predict output skills at T2?
2. after controlling for speech, nonverbal ability and age, does language performance or input skills at T1 predict output skills at T3?
3. after controlling for speech, nonverbal ability at T1 and age, does language performance or input skills at T2 predict output skills at T3?

Multiple regressions were calculated separately for the speech disordered and control group, using z-scores computed using the means and SDs from each group. Composite scores were used. Composite scores of expressive language, receptive language and speech input skills consisted of the same measures as was reported for the concurrent and longitudinal correlations: see section 9.2.6. For the speech output composite, articulatory naming was excluded in order to be consistent with the first set of regressions which also omitted this measure, due to lack of correlation with some other measures.

T1 predictors of T2 speech output:

Speech disordered group: at T1, speech performance is the best predictor of speech performance at T2.

Control group: no variable is uniquely predictive at the last step, but variance is shared between the language and speech input measures.

T1 predictors of T3 speech output:

Speech disordered group: at T1, speech performance is the best predictor of later speech performance. Language ability and input processing skills do not add any significant variance to the equation model once output skills have been accounted for. Input skills miss contributing significant unique variance ($p=.08$).

Control group: speech output is not a significant predictor of later speech skill. Previously, when age and nonverbal ability were not controlled for, speech output at T1 was found to be significantly predictive of speech output at T3 though speech input was more predictive when entered at the last step compared to speech output. When nonverbal ability and age are controlled for, speech output is no longer predictive. Speech input skill is the most predictive measure, contributing significant unique variance at the last step.

The influence of nonverbal skills is significant for the control group but not the speech disordered group.

T2 predictors of T3 speech output:

Speech disordered group: at T2, speech performance is an even stronger predictor than at T1 of later speech performance (59% of the variance after controlling for nonverbal ability and age). Expressive language ability adds 3% of significant variance to the model once input and output skills have been accounted for. T2 input processing skills predicted a significant 7% of additional variance in T3 output when entered at the last step.

Control group: additional language tasks did not predict later speech performance when entered after output but speech input does predict 7% of unique variance in T3 speech output. Nonverbal skills predicted significant variance for the control group but not for the speech disordered group.

Table 9.33.

Hierarchical multiple regression of T1 measures predicting speech output at T2

	Variables entered	Speech disordered group					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
Step 1	Age/ Nonverbal(T1)	.14	.10	.14	3.28	**<.05**	.17	.13	.17	4.50	**<.05**
Step 2	Output (T1)	.68	.65	.54	65.36	**<.001**	.37	.32	.20	12.92	**<.001**
Step 3	Expres (T1)	.71	.68	.03	3.71	.06	.45	.40	.09	6.35	**<.05**
Step 4	Recep (T1)	.71	.67	.001	.15	ns	.54	.49	.09	8.03	**<.01**
Step 5	Input (T1)	.72	.67	.01	.72	ns	.55	.48	.005	.42	ns
Step 2	Output (T1)	.68	.65	.54	65.36	**<.001**	.37	.32	.20	12.92	**<.001**
Step 3	Input (T1)	.69	.66	.01	1.38	ns	.44	.39	.07	5.35	**<.05**
Step 4	Recep (T1)	.69	.65	.002	.22	ns	.55	.49	.11	9.32	**<.005**
Step 5	Expres (T1)	.71	.67	.02	2.81	ns	.55	.48	.003	.22	ns

Table 9.34.

Hierarchical multiple regression of T1 measures predicting speech output at T3

	Variables entered	Speech disordered group					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
Step 1	Age/ Nonverbal(T1)	.12	.07	.12	2.59	.09	.29	.25	.29	8.03	**<.001**
Step 2	Output (T1)	.44	.40	.33	22.94	**<.001**	.35	.30	.07	3.96	.06
Step 3	Expres (T1)	.47	.42	.03	2.0	ns	.38	.32	.03	1.74	ns
Step 4	Recep (T1)	.47	.40	.00	.00	ns	.46	.38	.07	5.04	**<.05**
Step 5	Input (T1)	.51	.43	.04	3.15	.08	.52	.44	.06	4.79	**<.05**
Step 2	Output (T1)	.44	.40	.33	22.94	**<.001**	.35	.30	.07	3.96	.06
Step 3	Input (T1)	.50	.45	.06	4.22	**<.05**	.49	.44	.14	10.36	**<.01**
Step 4	Recep (T1)	.50	.43	.00	.01	ns	.52	.45	.03	2.08	ns
Step 5	Expres (T1)	.51	.43	.02	1.09	ns	.52	.44	.001	.06	ns

Table 9.35.

Hierarchical multiple regression of T2 measures predicting speech output at T3

	Variables entered	Speech disordered group					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
Step 1	Age/ Nonverbal(T1)	.03	-.01	.03	.72	ns	.29	.25	.29	8.03	**<.001**
Step 2	Output (T2)	.63	.60	.59	65.86	**<.001**	.44	.39	.15	10.42	**<.005**
Step 3	Expres (T2)	.67	.64	.05	6.3	**<.05**	.44	.38	.001	.07	ns
Step 4	Recep (T2)	.68	.64	.002	.26	ns	.46	.38	.02	1.3	ns
Step 5	Input (T2)	.75	.71	.07	10.53	**<.005**	.52	.44	.07	5.01	**<.05**
Step 2	Output (T2)	.63	.60	.59	65.86	**<.001**	.44	.39	.15	10.42	**<.005**
Step 3	Input (T2)	.72	.69	.09	13.51	**<.001**	.52	.47	.08	6.19	**<.05**
Step 4	Recep (T2)	.72	.68	.00	.001	ns	.52	.46	.005	.37	ns
Step 5	Expres (T2)	.75	.71	.03	4.26	**<.05**	.52	.45	.003	.19	ns

9.2.8. Relative contribution of speech processing measures to expressive language skills

The previous section reported that expressive language skill at T2 predicts unique variance in a composite measure of speech output at T3 for the speech disordered group. Whether speech processing skill predicts unique variance in expressive language skill is now explored. As reported in Table 9.36, speech output at T1 predicts additional unique variance in T2 expressive language once T1 expressive language has been controlled for. Speech output at T1 was not predictive after controlling for expressive language, for the longer term prediction of T3 expressive language; nor was there a unique predictive relationship between T2 measures and T3 expressive language (see Tables 9.37 and 9.38).

Table 9.36.
Hierarchical multiple regression of T1 measures predicting expressive language at T2

	Variables entered	Speech disordered group				
		R^2	Adjusted R^2	R^2 change	F	p
Step 1	Age/ Nonverbal (T1)	.21	.17	.21	5.04	**<.01**
Step 2	Expres (T1)	.63	.60	.42	42.80	**<.001**
Step 3	Input (T1)	.63	.59	.01	.49	ns
Step 4	Recep (T1)	.65	.60	.02	1.95	ns
Step 5	Output (T1)	.69	.64	.04	4.70	**<.05**
Step 2	Output (T1)	.40	.35	.19	12.27	**<.001**
Step 3	Input (T1)	.43	.37	.03	1.98	ns
Step 4	Recep (T1)	.62	.57	.19	18.48	**<.001**
Step 5	Expres (T1)	.69	.64	.07	7.75	**<.01**

Table 9.37.
Hierarchical multiple regression of T1 measures predicting expressive language at T3

	Variables entered	Speech disordered group				
		R^2	Adjusted R^2	R^2 change	F	p
Step 1	Age/ Nonverbal (T1)	.19	.15	.19	4.64	**<.05**
Step 2	Expres (T1)	.57	.54	.38	34.77	**<.001**
Step 3	Input (T1)	.57	.53	.001	.08	ns
Step 4	Recep (T1)	.59	.53	.01	1.15	ns
Step 5	Output (T1)	.59	.52	.001	.09	ns
Step 2	Output (T1)	.25	.20	.06	3.33	.08
Step 3	Input (T1)	.27	.20	.02	1.02	ns
Step 4	Recep (T1)	.46	.38	.19	12.66	**<.001**
Step 5	Expres (T1)	.59	.52	.13	11.16	**<.005**

Table 9.38.
Hierarchical multiple regression of T2 measures predicting expressive language at T3

	Variables entered	Speech disordered group				
		R^2	Adjusted R^2	R^2 change	F	p
Step 1	Age/ Nonverbal (T1)	.19	.15	.19	5.07	**<.05**
Step 2	Expres (T2)	.68	.66	.49	65.53	**<.001**
Step 3	Input (T2)	.69	.66	.008	1.02	ns
Step 4	Recep (T2)	.70	.66	.01	1.26	ns
Step 5	Output (T2)	.70	.66	.00	.00	ns
Step 2	Output (T2)	.30	.25	.11	6.74	**<.05**
Step 3	Input (T2)	.39	.33	.09	5.82	**<.05**
Step 4	Recep (T2)	.57	.52	.18	16.96	**<.001**
Step 5	Expres (T2)	.70	.66	.13	16.95	**<.001**

A summary of the role of expressive language skills in children with speech difficulties is presented in Figure 9.3. This summarises the previous series of regressions (section 9.2.5 and Figure 9.1) of the relationships between speech output and speech input skills over time (in order to retain the more detailed analyses when the predictor variables were individual rather than composite variables). The regressions including expressive language skill have been added to this summary. This shows the role of expressive language in predicting later speech output skills, as well as the role of speech output in predicting expressive language skills between T1 and T2. Also shown are the concurrent relationships between expressive language and speech processing (T1: expressive language and speech output, r=.65, p<.001; expressive language and speech input, r=.46, p<.005; T2: expressive language and speech output, r=.48, p<.001; expressive language and speech input, r=.51, p<.001; and T3: expressive language and speech output, r=.59, p<.001; expressive language and speech input, r=.33, p<.05).

9.2.9. The role of nonverbal ability and maturation

It was noted that nonverbal ability and age predicted different amounts of variance in speech output depending on group membership. In order to explore this further, multiple regressions were calculated entering age and nonverbal ability at separate steps. The results of these regressions are reported in Tables 9.39- 9.41. The measures account for more overall variance in the control group than the speech disordered group. For the speech disordered group, nonverbal ability at T1 is predictive at the last step of speech output at T3 (but not T2), and there are no significant effects of age. For the control group, both measures predict significant unique variance in later speech output tasks.

Table 9.39.

Hierarchical multiple regression of T1 measures of age and nonverbal ability predicting speech output at T2

	Variables entered	Speech disordered group					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
Step 1	Age (T1)	.05	.03	.05	2.35	ns	.20	.18	.20	11.40	**<.005**
Step 2	Nonverbal (T1)	.11	.07	.06	2.82	ns	.37	.34	.17	11.94	**<.001**
Step 1	Nonverbal (T1)	.03	.003	.03	1.14	ns	.08	.06	.08	3.73	.06
Step 2	Age (T1)	.11	.07	.08	4.04	.06	.37	.34	.30	20.74	**<.001**

Table 9.40.

Hierarchical multiple regression of T1 measures of age and nonverbal ability predicting speech output at T3

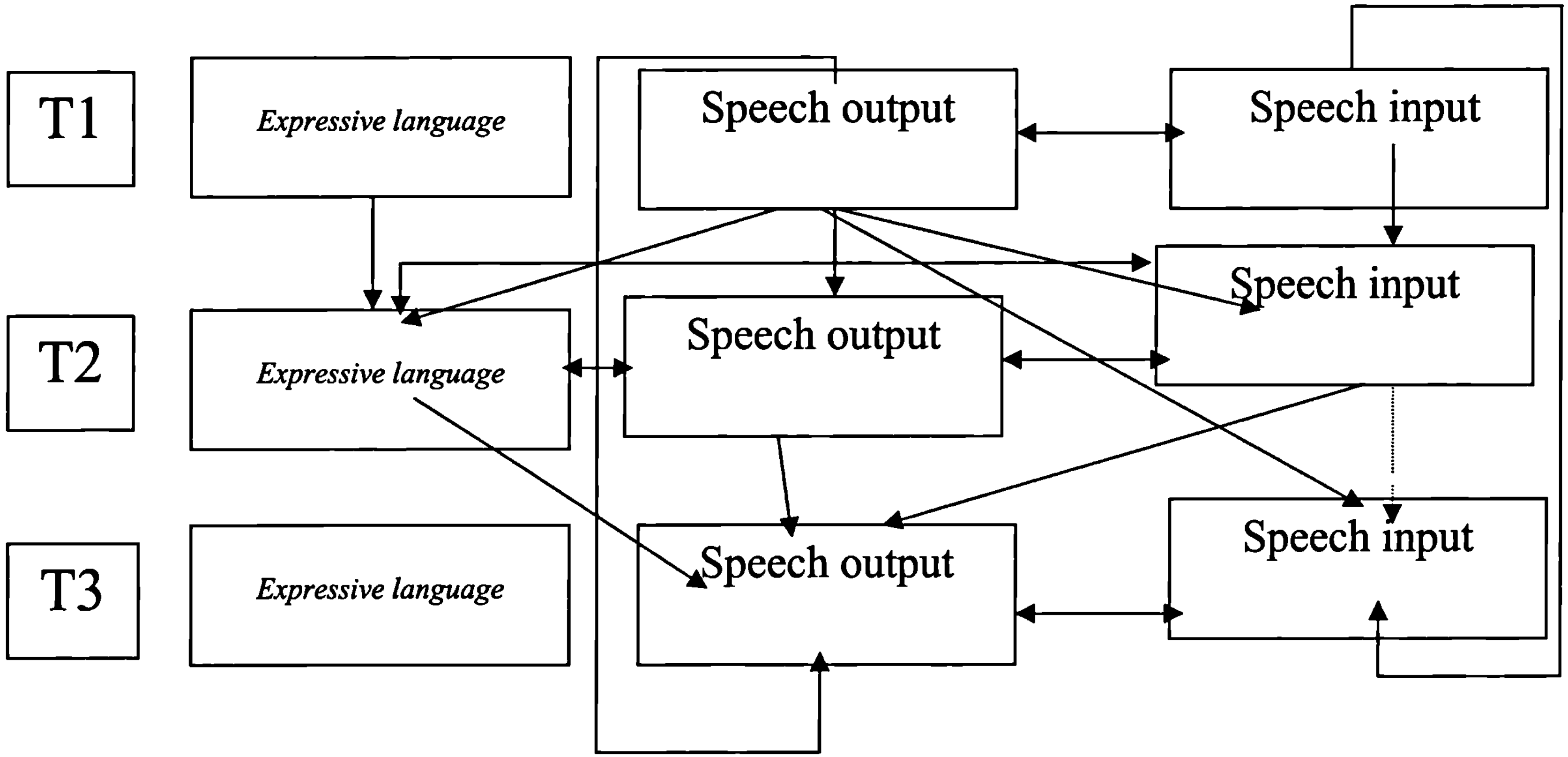
	Variables entered	Speech disordered group					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
Step 1	Age (T1)	.03	.01	.03	1.60	ns	.05	.03	.05	2.09	ns
Step 2	Nonverbal (T1)	.12	.08	.09	4.39	**<.05**	.24	.20	.19	10.34	**<.01**
Step 1	Nonverbal (T1)	.05	.03	.05	2.35	ns	.14	.12	.14	6.62	**<.05**
Step 2	Age (T1)	.12	.08	.07	3.92	.06	.24	.20	.10	5.56	**<.05**

Table 9.41.

Hierarchical multiple regression of measures of age at T2 and nonverbal ability at T1 predicting speech output at T3

	Variables entered	Speech disordered group					Controls				
		R^2	Adjusted R^2	R^2 change	F	p	R^2	Adjusted R^2	R^2 change	F	p
Step 1	Age (T2)	.02	.001	.02	1.05	ns	.04	.02	.04	1.72	ns
Step 2	Nonverbal (T1)	.11	.07	.09	4.37	**<.05**	.22	.18	.18	9.21	**<.005**
Step 1	Nonverbal (T1)	.05	.03	.05	2.35	ns	.14	.12	.14	6.62	**<.05**
Step 2	Age (T2)	.11	.07	.06	3.04	ns	.22	.18	.08	4.16	**<.05**

Figure 9.3.
Summary of unique predictors in multiple regression analyses: Relationships between components of the speech processing system and expressive language (Speech disordered group)



9.3. Discussion

9.3.1. Relationship between speech output tasks and relationship between speech input tasks

Differences were found in the degree of relationship between speech output tasks, depending on group membership. On speech input tasks, degree of relationship was similar across groups. An explanation for the different degrees of relationship on speech output tasks must be sought in the strong correlations of the speech disordered group rather than the weaker (though still highly significant) performance of the control group. As the tasks were designed to tap different aspects of speech processing skill, the controls' results indicate that there is a strong relationship between the different skills but not a perfect relationship, i.e. it is possible to argue that these tasks are indeed tapping related but different skills. The higher correlations of the speech disordered group show that these speech output skills are less differentiated for children with speech difficulties. We know from the means on these tasks that their speech difficulties are apparent across speech output tasks, rather than being mainly confined to poor performance on one type of task. Because of their difficulties, performance on one speech output task is extremely closely related to performance on others.

9.3.2. The relationship between speech input skills and speech output skills in normally developing children and children with speech difficulties

Strong relationships were found between the various speech processing measures. There were exceptions with the articulatory naming task being a weak correlate of other measures at T2 for the control group. One explanation for this finding could be that this task was designed as a lexical naming task and not to test articulatory naming. Forced choice responses were also included when calculating the percentage of consonants correct and this final score was bound up with a child's ability to access the correct lexical items. However, it is not apparent why this task showed significant relationships at T1 and T3 with other measures, but not at T2.

Putting aside this finding, different degrees of relationship were observed for each group. Speech output tasks correlated more highly with each other than with other measures for the speech disordered group compared to the control group. Generally, for controls, there is a similar degree of relationship across all speech processing measures. Results from the factor analysis for the control group showed all measures loading on only one factor. On the one hand, this demonstrates the relationship to be a strong one, highlighting the importance of the majority of these tasks within one system. On the other hand, since the correlations between measures were not exceptionally high, these skills, whilst interdependent and interactive, can be conceptualised as separable entities, reflecting their differentiation in theoretical models of speech processing.

For the speech disordered group, all speech processing measures also loaded on one factor. However, inspection of the correlations revealed there is a relatively greater division between speech input and speech output tasks (apparent in the greater relationships between speech output tasks than speech input tasks in the correlations and in the lower loading values of the speech input tasks compared to the speech output tasks). This is likely to be attributable to the way the children were recruited. They were recruited to the study because of their speech output difficulties and not their speech input performance. Since not all of the speech disordered group was subsequently found to have speech input difficulties, there is a mismatch between speech input and output skills in the group. This mismatch is relevant to how we interpret the higher correlations found amongst the speech output tasks compared to the controls' results. Because of their obvious speech output difficulties, performance on one speech output task is extremely closely related to performance on others: disorder is pervasive through this aspect of the speech processing system. This pattern also holds over time, despite improvements in this group's speech output performance with age. However, because performance on input skills is less extreme than that of output skills and there is less variance, there is a lesser degree of correlation between input skills.

Alternatively, if items of the input tasks had been matched to the individual's output errors, a higher degree of correlation might have been obtained, and might have uncovered a one-to-one relationship between input and output. However, this approach, adopted by Bird and Bishop (1992), failed to uncover such a relationship. They found speech severity correlated with one of their measures of input (AD: words) but not the other (AD: nonwords). Moreover, this strategy would have been a problematic one to employ in a prospective longitudinal study. As some children's speech output difficulties resolved at T2 and T3, there would have been little material on which to base the items, resulting in another set of methodological problems. In the way these tasks were designed for the current study, using a broad range of speech sounds, it was possible to establish general patterns of association.

In summary, these findings show that speech output and speech input skills are closely related, though differentiated to some extent. The factor analyses showed that speech output and speech input tasks loaded on the same factor, which could be termed one speech processing factor. Importantly, this demonstrates that, when considering speech skills, speech input skills must be seen as an integral part of the speech processing system.

9.3.3. The predictive relationship between speech output skills and speech input skills

Speech output and speech input skills were found to be predictive of later speech output skills in both the control group and the speech disordered group. Measures of these skills accounted for between 43-74% of variance in later measures for the speech disordered group (an average of 58%). For the control group, the amount of variance was less, with an average of 35% of variance accounted for. Conversely, analyses discussed in Section 9.3.4 show a greater role of maturation and nonverbal skills in the control group than the speech disordered group.

For the control group, with one exception, both earlier speech output and speech input were uniquely predictive of later speech output skills when either were entered at the last step. Input and output are therefore clearly differentiable processing skills as they both contribute unique variance in later output skills. At the same time, both types of processes are related to later speech development, i.e. the speech processing system (with separable components) predicts output skills. The exception was that speech output at T1 was not predictive of nonword repetition at T3.

For the speech disordered group, speech output at T1 was uniquely predictive of T2 and T3 speech output. There was shared variance with input skills but these skills at T1 predicted no unique contribution on later speech output skills. Speech input at T2 did, however, predict some unique variance in T3 speech output (between 4-14%). The role of input is less differentiated from output for this group, with output being the main unique predictor.

An important role for input processing in normal speech output development has therefore been uncovered. Indeed, for the control group, speech input skills predict T3 nonword repetition, while speech output skills offer no unique prediction. For the speech disordered group, the role of input processing is subsumed by that of output skills, with input at T1 sharing variance with output skills. At T2, speech input skills do predict unique variance in T3 repetition skills, though the unique prediction of speech output is greater at the last step.

Despite these differences between groups, it is important to note that at the first step, speech input skills do predict similar amounts of variance across groups (with the exception of T2 speech input with T3 word repetition, where it contributes greater variance for the speech disordered group (53%) than the control group (32%) which could be attributable to the more restricted variance associated with high scores for the control group). T1 speech input skills predict an average 18% of variance in T2 speech output for the speech disordered group at the first step, compared to 25% for the controls. Similar amounts of speech input skills predict T3 speech output skills (an average 22% for the speech disordered group; and 28% for controls) at the first step. Thus, rather than speech input skills having different predictive roles in the two groups, it seems that it is the role of speech output skills that differs, with speech output playing a much more significant role in later speech skills for the speech disordered group. This is confirmatory of the correlations and factor analyses that showed stronger relationships between the speech output measures for the speech disordered group than the control group.

Looking at the reciprocal relationship, i.e. the relationship between earlier speech output skills and later speech input skills, less overall variance was accounted for by earlier speech processing skills, compared to the prediction of speech output skills. For the speech disordered group, an average of approximately 25% of variance was accounted for between T1 measures and T2 speech input; less variance was accounted for by the prediction of the AD: picture task at T3, but more variance in the prediction of AD: ABX at T3. On occasion, speech output is predictive of speech input for the speech disordered group. For the speech disordered group, speech output at T1 was uniquely predictive of T2 AD: picture task and of

T3 AD: ABX task. For the controls, it is also varied to some extent, though speech output was only uniquely predictive at T2 of T3 AD: picture task but there were ceiling effects on this auditory task, so this result is discounted. It is therefore apparent that for the speech disordered group, speech output skills may exert a causal influence on the development of speech input skills. As well as establishing that speech input skills are predictive of later speech output skills, these results show that current speech output skills will influence future speech input skills, though to a lesser degree. This is a more dynamic and interactive system for the speech disordered group. For both groups, however, speech input is a better predictor of later speech output skills, than speech output skills are of speech input.

Since there are issues surrounding distribution of scores in some of the tests used and distribution according to group, it would be unwise to over-emphasise the differences between groups on significant predictors. Instead, taking an overall view of these series of regressions, it seems more appropriate to conclude that there are broad similarities in these children's development, with some important exceptions - notably a stronger reciprocal role of input and output for the speech disordered group, and also a role for expressive language (see next section). Overall, speech input seems to predict similar amounts of variance in later speech skills for both groups when entered at the first step of the regressions. It is the effect of speech output skills that is more predictive in the speech disordered group of later speech output skills. The stronger role of output skills suggests that disordered development is specifically mediated by the severity of the children's output problems. Differences on speech output may also be mediated by differing variance of scores between groups, with some ceiling effects in the control group, lessening its potential predictive role. Nevertheless, even with well developed speech skills, speech input processing plays an important predictive role in normally developing children, notably for nonword repetition, where one's earlier input skills are of greater importance than articulatory ability in listening to and repeating unfamiliar stimuli. The role of input is similar in the speech disordered group when entered at the first step, although importantly output shares variance with input skills.

9.3.4. Predictive role of language skills, nonverbal ability and age

Language ability does play a minor predictive role in speech development for the speech disordered group. Associated language difficulties were identified in a subgroup of the cohort (Chapter 6) and poorer speech outcome was related to additional language difficulties (Chapter 7). In this chapter, general relationships were found between language and speech processing skill for both groups and a small predictive relationship was established between T2 expressive language and T3 speech output for the speech disordered group but not the control group. This could suggest that the language difficulties this group have, play a causal role in the further development of their speech skills rather than being just an associated/co-occurring problem. However, the relationship is complex, as earlier speech output skills mediate later expressive language skills in the speech disordered group as well. Children with more severe speech difficulties will be less successful than others on expressive language tasks. This result may have tapped into the issue of intelligibility with children with poorer intelligibility less able to mark morphology and aspects of syntax with a limited sound system. Again, this reveals the highly complex and interactive system of development of the speech processing system. Importantly, this result shows that language skills can be seen as an important component of this developing system. Further evidence for this comes from the factor analysis of the control group, which found a main factor consisting of speech processing skills and the majority of language measures, indicating that there was a high degree of correlation between such measures. However, dissociation was shown in the finding of two factors - a speech processing factor and a language factor - for the speech disordered group. This reiterates that speech and language skills are separable, and children with speech difficulties can show dissociable performance on these skills. Particularly, it shows that, whilst speech intelligibility may play a role in expressive language performance (RAPT grammar loaded on the processing factor), language skills in the speech disordered group are generally independent of speech processing skills. Nonetheless, a developmental perspective allows the close relationships between these skills to be described.

Nonverbal ability and age (i.e. maturation) predicted significant and unique variance in speech output skills for the control group, showing that more general aspects of development are influential in speech development. This was not the case for the speech disordered group, where maturational effects were not predictive, though nonverbal skills influenced later speech development to some extent. For the speech disordered group, development is mediated primarily by speech and language skills, i.e. the severity of their initial difficulties, rather than by more general developmental factors, as was found in the control group.

9.3.5. Summary

The study of associations of skills has highlighted the importance of considering the whole speech processing system, as well as language skills, when examining normal and atypical speech development. Speech input skills, in particular, were found to play an important role in speech output skill, even for normally developing children who have well developed and accurate speech output skills. For the speech disordered group, a reciprocal role of input and output skills was uncovered. Implications of these findings, both theoretical and clinical, in terms of characterising the nature of speech difficulties and in linking the findings to the patterns uncovered in the subgroup analyses, are explored in Chapter 11.

Chapter 10
The role of speech variability in speech development

10.1. Introduction

The aim of this chapter is to explore speech input processing in further depth. A key, but neglected aspect of speech processing skills is the ability to process different aspects of speech variability. An experiment will be presented that examines how children with and without speech difficulties process speech variability, in particular, the systematic variability of accent variation.

10.1.1. Discussion of previous findings on speech input tasks

Analysis of the data from the longitudinal study of children with and without speech difficulties established that measures of speech input can predict later speech output skills and are thus sensitive markers of speech development. The three tasks used to measure 'speech input' (AD: picture task, AD: ABX task, AD: same/different task) are fairly typical testing paradigms used both clinically and in research. In the first task, the child is required to compare a spoken stimulus to his/her own phonological representation of the item and then judge whether the spoken stimulus is an accurate realisation of this representation. In the latter two tasks, the child must compare and contrast spoken stimuli and decide whether these stimuli have been said in similar or different ways. The assumption underlying these three tasks is that a child must have an ability to process speech input in different ways and a poor ability in these areas may co-occur with delayed or disordered speech development. In the case of the AD: picture task, a correct version of the spoken word is presented which can be matched to an existing representation or an incorrect version that must be rejected. In the case of the AD: ABX and same/different tasks, while the child does not need to compare the stimuli to existing representations, there is the assumption that being able to detect sameness or difference is an important prerequisite for developing correct phonological representations and motor programs. This way of assessing speech processing skill has some limitations. First, it looks at speech processing at a single word level. At a phrase or sentence level, processing demands may be quite different. Second, this view of speech processing does not centrally address the issue of speech variability. The speech stimulus is not a stable, invariable signal that can or cannot be assessed by the listener as, in some sense, 'accurate', but is in fact a highly variable and transient phenomenon. Forrest, Chin, Pisoni et al. (1994) argued that, given the limited findings of a relationship between speech production and speech perception in children with speech disorders, addressing the issue of speech perception from a different angle could be profitable (in their case, examining speaker normalization by comparing a single versus multiple talker condition).

The results from the longitudinal study have extended our understanding of this relationship, in particular, the multiple regression analyses of Chapter 9, showing that, especially for the control group, the speech input tasks were predictive of later speech development; although, like other studies (i.e. Bird & Bishop, 1992), speech input deficits were found in only a subgroup of the sample (Chapter 7). Thus, we can build on our previous findings that show the importance of an intact speech processing system (especially speech input skills), and also move towards examining this population from a novel angle. Without phonological representations in place, and without an age-appropriate ability to discriminate speech sounds, it is likely that children with speech problems will have difficulties processing complex and variable phonetic/phonological material.

10.1.2. Accent variation

Accent variation is a particularly relevant type of cross-speaker variability to examine in relation to children's speech processing systems, as young children are learning language, which integrally involves developing their own accent systems, at the same time as they must process the different types of variability inherent in the speech signal. Sets or systems of phones are acquired during the first stages of language development: accent variation could therefore influence young children's speech output in a way qualitatively different to other types of variability. There may be an interaction between the change/development occurring in the developing speech and language system and the processing of the unfamiliar phonological and phonetic forms. Indeed, it has been found that children may find processing accent variation problematic. In a series of experiments, children in the age range 4-9 years were found to perform less well on repeating and defining words presented in an unfamiliar accent compared to their own local accent (Nathan, Wells & Donlan, 1998; Pate, 1998; Collins, 1998).

The processing demands of repeating and defining a word in an unfamiliar accent is hypothesised using Stackhouse and Wells' speech processing model, as illustrated in Figure 10.1. 'Phonetic discrimination' is needed in order to extract the novel phonetic information from the word spoken in an unfamiliar accent, for instance, the particular quality of the rime of Glaswegian BEAR, [eɹ]. Once this has been extracted, it can then be mapped onto a phonological unit in the child's accent, stored at 'phonological recognition'- either onto the rime /ɛə/, giving correct access to the phonological representation of BEAR, or onto the rime /ɪə/ giving incorrect access to the phonological representation of BEER. Alternatively, the child may fail to map the stimuli altogether, with no appropriate phonological representation accessed.

The formation of language-specific phonological representations is likely to be influenced or have been influenced in the past, by 'bottom-up' auditory discrimination abilities. There may also be a top-down influence from the size of the child's vocabulary: as a child's vocabulary grows, phonological representations become increasingly segmented and detailed in order to allow for sufficient differentiation between lexical items (Walley, 1993). Age differences in accent processing may therefore be attributable in part to the size of the lexicon.

Thus it is likely that both bottom-up and top-down processing factors play a role in the development of phonological representations and in the development of the related ability to comprehend words spoken in unfamiliar accents. As some children with speech difficulties have been shown to have low performance in auditory discrimination and/or in vocabulary development, it can be hypothesised that they are likely to have difficulties in understanding unfamiliar accents.

Figure 10.1.
Stackhouse and Wells' speech processing model (1997): speech input processing

Image has been removed for copyright reasons

10.1.3. Accent auditory lexical decision task

In order to address these issues, an experiment was designed comparing the performance of normally developing children to that of children with speech difficulties. Two versions of an auditory task were presented, one in the participants' own accent and the other in an unfamiliar accent. For each condition, the child was presented with a series of pictures. On the presentation of each picture, the child heard a spoken stimulus and had to decide whether the spoken stimulus matched the picture, i.e. whether the picture had been named accurately. By asking whether or not the child had heard a lexical item that represented the picture, the child was being encouraged to respond at a lexical level rather than a level of pronunciation (i.e. whether it sounded unusual or odd). This paradigm closely resembles a lexical decision task that requires subjects to decide whether a stimulus is a word or a nonword, a procedure that is used to study word recognition and the nature of the lexicon (Goldinger, 1996). In its use of pictures, the procedure parallels the AD: picture task of the main test battery. This task will be referred to as an accent auditory lexical decision task. The act of rejecting a nonword is based on a lexical search: if the stimulus fails to match any item that the child has already stored in his lexicon, the stimulus must be rejected. As well as tapping processing levels, the present experimental task has functional currency, since in the real world the child has to be able to map variant phonetic stimuli onto stored representations in order to achieve successful lexical access.

In the 'own accent' condition, children perform a fairly standard lexical decision procedure, accepting as words or rejecting as nonwords phonetic stimuli presented in the native accent system of their speech community. In the unfamiliar accent condition, the child needs to decide whether a phonetic stimulus, which differs from the child's own accent in its phonetic detail, nevertheless counts as a possible realisation of a lexical item for which the child already has a stored representation. The task demands that the child accepts stimuli that contain permissible accent-related variation but rejects those stimuli whose phonetic form does not count as a possible realisation of a stored word, even within the unfamiliar accent.

What speech processing mechanisms might account for a child's decision to accept or reject stimuli in an unfamiliar accent? Poor performance on the unfamiliar accent condition could be associated with poor mapping from the variant phonetic stimulus onto 'phonological recognition', which contains the child's inventory of familiar, English phonetic patterns. According to Stackhouse and Wells (see Figure 10.1), there is a processing level termed 'phonetic discrimination', where unfamiliar sounds can be discriminated and mapped onto the phonological units of the child's own accent (in 'phonological recognition'). If this mapping fails to occur, successful lexical access cannot take place.

If, however, a child also performs poorly on the 'own accent' condition, deficits might be occurring at different levels. It is possible that phonological representations are poorly or inaccurately specified, leading the child to reject words and/or accept nonwords as words, irrespective of whether the phonetic stimuli are presented in their own accent or in an unfamiliar accent.

Alternatively, poor performance may be associated with deficits or a history of deficits at the level of 'phonological recognition'. According to Stackhouse and Wells (1997), phonological recognition is the level tapped by word/nonword auditory discrimination tasks. Deficits at the level of phonological recognition are likely to result in the child developing poorly specified phonological representations, because the input from phonological recognition to the phonological representations is faulty. Deficits in phonological recognition will also mean that on-line access to lexical phonological representations is less accurate. In order to examine whether this level of processing is implicated in the processing of unfamiliar accents, two tasks used in the main test battery were compared with this: the AD: same/different task and the AD: ABX task. If the child is successful on the auditory discrimination tasks but fails on the unfamiliar accent auditory lexical decision task, this will support the interpretation that the deficit is in phonetic discrimination. On the other hand, if the child performs poorly on these auditory discrimination tasks as well as on the accent auditory lexical decision task, it will not be possible to rule out deficits at the level of 'phonological recognition'.

In summary, this chapter reports a study examining the speech input processing skills of children with speech difficulties and focuses in particular on their ability to process accent variation. Tasks were administered that tapped: (a) phonological recognition, through auditory discrimination tasks (from the main test battery, as previously reported); (b) phonological representations, through the 'familiar accent' condition of an accent auditory lexical decision task and (c) phonetic discrimination, through the 'unfamiliar accent' condition of the accent auditory lexical decision task.

10.2. Method

10.2.1. Participants

Eighteen children with speech difficulties and 18 normally developing children were selected from the main cohort, one year after they had been referred to the larger study at age 5. The normally developing group had a mean age of 5;09 (range 5;03-6;05) (6 girls and 12 boys) and the speech disordered group had a mean age of 5;11 (range 5;01-6;04) (5 girls and 13 boys). The 2 groups did not differ significantly on age or nonverbal ability. All children had performed within normal limits on the nonverbal measures of Block Design and Picture Completion Tests, (Wechsler, 1992) administered one year earlier.

The children originally selected with speech difficulties still had current speech difficulties. Current speech difficulty was defined as a score of at least –1 SD below the controls' mean using the LF word repetition task. This subgroup also followed the pattern of those children with persisting speech difficulties who also had additional language difficulties. Means and SDS of these skills are reported in Table 10.2.

Table 10.1.
Means and SDs of age, nonverbal ability and word repetition skill by group

	Speech disordered group (n=18)	Control group (n =18)
Age	5.69 (.36)	5.93 (.29)
Block Design	11.07 (2.43)	11.43 (1.65)
Picture Completion	12.20 (1.70)	12.71 (2.13)
Word repetition*	51.89 (20.54)	93.30 (5.01)

Note: SDs in parentheses
*Percentage of consonants correct

Table 10.2.
Means and SDs of the Speech disordered group and the Control group on language measures

	Speech disordered	Controls	T value
Renfrew Bus Story (information score)	21.67 (8.87)	29.44 (6.26)	-3.04[b]
Renfrew Bus Story (MLU)	8.08 (2.52)	11.06 (2.38)	-3.64[c]
RAPT (information score)	31.75 (2.95)	34.06 (3.73)	-2.06[a]
RAPT (grammar score)	19.44 (3.96)	25.50 (5.06)	-4.0[c]
Naming task	7.94 (2.10)	12.39 (3.27)	-4.85[c]
BPVS (standard score)	94.83 (12.68)	109 (10.13)	-3.57[c]
TROG (number of blocks)	10 (2.93)	12.94 (1.95)	-3.47[c]

Superscript: [a] $p<.05$; [b] $p<.01$; [c] $p<.001$
Note: SDs in parentheses

10.2.2. Accent auditory lexical decision task

10.2.2.1. Design and Stimuli.

An auditory lexical decision task with pictures was designed with two accent conditions: condition 1: a version of the participants' own native, London accent and condition 2: an unfamiliar accent, Glaswegian. A Glaswegian accent was chosen as the unfamiliar accent because Glasgow is geographically remote from London, where the children live, and because the accent has a number of striking phonetic and phonological differences from that of London and from more standard varieties of Southern British English. These include systemic and realisational differences in the vowels, and the occurrence of post-vocalic /r/ (Wells, 1982; Stuart-Smith, 1999). Two word lists of 12 items were designed in both accents (London Regional Standard and Glaswegian) that were selected from items from a previous experiment where words were matched across lists by word frequency and phonological vowel (see Nathan, Wells & Donlan, 1998, for details about the design and appendix for test items). All stimuli were one syllable in length. One-syllable words were selected to ensure close matching across lists: many of the matchings consisted of minimal pairs. As the stimuli were presented as pictures as well as auditorily, only imageable words were selected from the lists used in the earlier study. Nonwords were derived from each word by changing the voicing, place or manner of articulation of one consonant of the target word. The same Glaswegian informant from the Nathan et al. (1998) study was used.

The accent used by this informant accords closely to the description of a Glaswegian accent given by Wells (1982). Systemic differences include a lack of three pairwise phonological oppositions between distinctive monophthongs: [ʊ] and [uː]→[ʏ], [æ] and [ɑː]→ [a], [ɒ] and [ɔː]→ [ɔ]. The collapse of these contrasts includes the loss of both the vowel quality difference and the length difference found in the London accent. Phonetic realisational differences include:

London		**Glaswegian**
[ɑɪ]	=	[ʌi]
[əʊ]	=	[o]
[æʊ]	=	[ʌʏ]
[ɛɪ]	=	[e]
[ɛː]	=	[eɹ]
[ɜ̟ː]	=	[ʌɹ]

As the last two items illustrate, the Glaswegian accent is rhotic for many speakers, including our informant: the informant uses a postalveolar approximant following the vowel in words such as BIRD and FORK. This contrasts sharply with the London accent, where the postalveolar approximant is only found prevocalically. Features common to both the Glasgow and the London accent, as represented by the informants, include the use of a glottal stop without lingual closure for the consonant at the end of words such as KITE and COAT, and the preglottalization of coda voiceless stops, in words such as SOCK and ROPE. In both accents, this is one of the features that serves to distinguish pairs such as LOCK and LOG or ROPE and ROBE, particularly as in both accents, the final stop consonant will be phonetically voiceless in both words of the pair.

10.2.2.2. Procedure

The two lists were recorded on audiotape in both accents for presentation and played back on a Phillips AQ6350 cassette recorder. Line drawings of each item were presented. Although the items were all familiar words, the examiner checked whether the child recognised the pictures before the main task: the child either named the picture or, if unsure of the picture, repeated what the examiner named. The child was asked to look at the picture and decide if a pre-recorded word was the name of that picture (e.g. picture of a BOX presented and the child hears "MOX", or "BOX"). The child must simply respond 'yes' or 'no' to each item presented. Two spoken stimuli were presented with each picture for half the items and three spoken stimuli for the other half of the items (their order randomised). The third presentation, which could be either correct or incorrect (i.e. BOX or MOX), was introduced to reduce the possibility of the child predicting the next presentation, but this item was not scored. One practice item was administered first when corrective feedback was given as appropriate (though children found the task straightforward). Half the children received List A in their own accent and List B in the Glaswegian condition; the other half of the group received List A in Glaswegian and List B in their own accent, in order to control for the effect of individual stimuli. The order in which the accent was presented was randomised, i.e. some children received the London accent first while other children received the Glaswegian accent first.

Short extracts from two 'Mr. Men' books (Hargreaves, 1971, 1976) were also pre-recorded, one by the London regional standard speaker, the other by the Glaswegian speaker, and presented before the relevant word list. This served to familiarise the participants to the voice of presentation. In particular, listening to the unfamiliar accent gave the children controlled exposure to the Glaswegian phonological system. This was done to ensure that the task that followed would then be testing the child's ability to process items from a different phonological system, rather than simply to interpret exotic phonetic forms.

The accent tasks took approximately 20 minutes to administer, and were carried out at the same time as the main test battery described in Chapter 3. Testing was carried out over a series of short sessions in a quiet room of the child's school or home. The accent tasks were, where possible, administered in their entirety during one session.

10.3. Results

As all the speech input tasks had forced choice responses, raw scores were transformed to values of d' (as described in Chapter 3, section 3.4.7). A d' score was calculated based on each subject's hits and false alarms. The hit rate was defined as the proportion of words to which the subject correctly responded 'yes', and the false alarm rate was the proportion of nonwords incorrectly identified as words (i.e. also responding 'yes'). Table 10.3 shows *d'* means, SDs and ranges of scores by group for the two conditions.

Table 10.3.
Means, SDs and ranges of scores of the two conditions of the accent auditory lexical decision task by group (*d'* and bias (c) scores)

	Speech disordered group (n =18)				Control group (n =18)			
	d'		c		*d'*		c	
	M(SD)	Min-Max	M(SD)	Min-Max	M(SD)	Min-Max	M(SD)	Min-Max
London	2.36 (.72)	1.11 - 4.08	-.12 (.04)	-.2 - -.06	2.42 (.53)	1.11 - 3.16	-.12 (.03)	-.16 - -.06
Glaswegian	1.42 (.90)	0 - 3.16	-.07 (.05)	-.16 - 0	2.55 (.57)	1.75 - 3.5	-.13 (.03)	-.18 - -.09

10.3.1. Accent auditory lexical decision task

A repeated measures ANOVA with one within factor of Accent (with 2 levels: London and Glaswegian) and one between factor of Group (with 2 levels: Speech disordered and Controls) was conducted. Two significant main effects were uncovered, of Accent ($F(1,34) = 10.16$, $p<.01$) and of Group ($F(1,34) = 9.36$, $p<.005$). There was also a significant interaction of Accent x Group ($F(1,34) = 17.64$, $p<.001$). Simple effects exploring the interaction showed that there was a significant difference between accents for the speech disordered group ($F(1, 34) = 27.29$, $p<.001$) but no significant difference between accents for the control group ($F(1,34) = .51$, ns), i.e. the speech disordered group performed significantly less well than controls on the Glaswegian condition compared to the London condition.

There was a significant difference between the two groups on the Glaswegian condition, ($F(1,34) = 20.12$, $p<.001$). A majority of the speech disordered group, 66.7% (n=12), scored at least –1 SD below the control group's mean on the Glaswegian condition. There was, however, no difference between the controls and the speech disordered group on the London condition ($F(1,34) = 0.07$, ns) (only 16.7%, n=3, of the speech disordered group scored at least –1 SD below the control group's mean).

10.3.2. Error analysis

Two types of errors were possible in the accent auditory lexical decision task:

erroneously rejecting a word and erroneously accepting a nonword. The pattern of errors is shown in Table 10.4. In the Glaswegian condition, there are more errors rejecting words than in accepting nonwords. In the London condition there are more errors in accepting nonwords than in rejecting words; there was a negligible number of errors in rejecting words.

In order to verify whether there was a bias towards one type of response, response bias scores were calculated (Macmillan & Creelman, 1991), as reported in Table 10.3. A paired samples t-test was then calculated that compared response bias scores across the conditions. This showed a significant difference in bias according to whether the stimuli were presented in a Glaswegian or London accent ($t\ (35) = 2.62$, $p<.05$). Response bias did not differ significantly between controls and the speech disordered group in the London condition ($t\ (34) = -.19$, ns) but did differ significantly in the Glaswegian condition ($t\ (34) = -4.11$, $p<.001$).

Table 10.4.
Means and SDs of types of errors by group on the accent auditory lexical decision task (*d'* score)

	Speech disordered group (n =18)	Control group (n =18)
London NW accept	2.56 (2.01)	2 (1.28)
London RW reject	1.06 (1.26)	1.11(1.37)
Glaswegian NW accept	1.78 (1.96)	.89 (1.02)
Glaswegian RW reject	4.94 (2.84)	1.78 (1.44)

Key: NW accept: accepting a nonword as a word
RW reject: rejecting a word
Note: SDs in parentheses

10.3.3. Performance on other speech input measures

Means and SDs for the AD: same/different and the AD: ABX task are reported in Table 10.5 for the subset of children who were administered the accent tasks. Independent samples t-tests revealed significant differences between groups, with the control group scoring better than the speech disordered group: AD: ABX ($t\ (34) = 3.98$, $p<.001$) and AD: same/different ($t\ (34) = 2.15$, $p<.05$).

Table 10.5.
Means, SDs and ranges of scores of the AD: same-different task and the AD: ABX task (*d'* score)

	Speech disordered group (n =18)		Control group (n =18)	
	M(SD)	Min-Max	M(SD)	Min-Max
AD: same-different	2.57 (1.04)	.8 - 3.92	3.25 (.85)	1.13 3.92
AD: ABX	.95 (.97)	-1.12 - 2.12	2.33 (1.12)	-1.12 - 3.24

Note: SDs in parentheses

Correlations are reported in tables 10.6. and 10.7. For the speech disordered group there was a significant correlation of the London and Glaswegian accent condition. The Glaswegian accent condition also correlated significantly with two of the speech input tasks: AD: picture task and AD: same/different task. There were no significant correlations with speech output.

For the controls there was a significant correlation of the Glaswegian accent condition with the AD: same/different task.

Table 10.6.
Correlations of the two accent tasks with other auditory measures (Speech disordered group)

	London	Glaswegian	AD: ABX	AD: Pic	AD: S/D	LFWRpcc	LFNWpcc
London	-						
Glaswegian	.71*	-					
AD: ABX	.45	.39	-				
AD: Pic	-.03	.56*	.28	-			
AD: S/D	.46	.55*	.72**	.13	-		
LF RWpcc	.29`	.37	.16	.29	.06	-	
LFNWpcc	.32	.44	.05	.21	.07	.91**	-

*p<.05

**p<.01

Table 10.7.
Correlations of the two accent tasks with other auditory measures (Control group)

	London	Glaswegian	AD: ABX	AD: Pic	AD: S/D	LF RWpcc	LFNWpcc
London	-						
Glaswegian	-.47	-					
AD: ABX	-.36	.23	-				
AD: Pic	-.17	.48	.79	-			
AD: S/D	-.24	.52*	.47*	.79**	-		
LF RWpcc	-.02	.32	.18	.57*	.16	-	
LFNWpcc	.-.30	.26	.44	.61*	.36	.36	-

*p<.05

**p<.01

10.4. Discussion

The results of this study showed that the children with speech output difficulties had a specific deficit on the matched accent task compared to the own accent task. They also performed less well than controls on the two auditory discrimination tasks. The implications of this pattern of performance will now be explored.

The speech disordered group performed less accurately than controls in a Glaswegian version of an auditory lexical decision task with pictures, compared to one presented in their own native accent. Accent variation disrupted their ability to identify accurately whether a word had been spoken correctly. The speech disordered group performed similarly to controls on the London condition of the task. Therefore, on this matched task, accent discriminated between the disordered and the control group. This suggests that, overall, the speech disordered group do not have a general and pervasive difficulty arising from grossly inaccurate phonological representations: if that had been the case, they would have performed less well than controls on the 'own accent' condition too, since both tasks involved rejecting nonwords that were phonetically similar to real words stored in the lexicon.

In the Glaswegian condition, the speech disordered group showed a significant bias towards erroneously rejecting words, i.e. treating them as nonwords. The Glaswegian form of the word that was presented as the stimulus was so different from the child's own representation of the word, that, on occasions, no lexical item was triggered or accessed. According to Stackhouse & Wells' model (1997), this suggests that the difficulty the children had with the Glaswegian condition lay with the discrimination of the unfamiliar phonetic features of the Glaswegian stimuli, and the mapping of these variant forms onto the child's phonological units that are stored at the level of phonological recognition: see Figure 10.2.

Figure 10.2.
Stackhouse and Wells' speech processing model (1997) showing the processing routes used for the London and Glaswegian conditions and the postulated loci of difficulty for the Speech disordered group.

Image has been removed for copyright reasons

In the London condition, by contrast, the children with speech difficulties were able to map the phonetic stimulus onto the appropriate phonological units stored at phonological recognition. This enabled the appropriate phonological representation to be accessed. Because the stimuli are familiar, phonetic discrimination can be bypassed: see Figure 10.22.

To summarise the findings of the accent tasks: when the accent was unfamiliar, the performance of the children with speech difficulties dropped. This suggests that their processing of accent-related variability is specifically disrupted. However, significant group differences were also found on the two auditory discrimination measures (AD: same/different and AD: ABX). What does performance on these other two tasks tell us about these children's speech input skills? It could suggest that children with speech difficulties do indeed have problems at the level of phonological recognition, by being poorer than controls on the auditory discrimination of similar sounding words and nonwords. Their speech input difficulties thus involve both phonetic discrimination and phonological recognition.

The location of the children's difficulties at lower input levels of the speech processing model is consistent with findings by Groenen et al. (1996). They compared the performance of 8-year-old Dutch children, diagnosed clinically as having developmental apraxia, on what they termed measures of 'auditory processing' and 'phonetic processing'. They used an identification task and a discrimination task, using a seven-step [b-d] continuum. The identification task was hypothesised to test phonetic processing because the child must classify each stimulus (from somewhere along the continuum) using a phonemic judgement of which endpoint the stimulus most closely resembled; the discrimination task, although it contrasted points along the same continuum as in the identification task, was thought to tap auditory processing ability as well as phonetic processing. Results showed that the children with the diagnosis of developmental apraxia were poorer than controls at discriminating monosyllabic words. However, they performed equivalently to controls on the identification task using the same continuum, which, according to the authors, shows that phonetic processing ability is intact while auditory processing is impaired in this group. By contrast, our findings do not support Bird and Bishop's study (1992), where they argue that the input deficit of their sample of 14 children with speech difficulties lies with the ability to perceive phoneme constancy and is reflected in reduced awareness of the internal structure of phonological strings.

The results of this study show that locating a speech input processing deficit at one single level is problematic. The way these skills is measured is crucial, with comparison of performance across the accent tasks revealing deficits at the level of phonetic discrimination but performance on the other auditory measures showing deficits at phonological recognition. Additionally, results from Chapter 8 in particular caution against the identification of very specific speech processing difficulties, as comparing across tasks is problematic when tasks differ in their demands. Instead, the notion of a highly interactive processing system was proposed in Chapter 9, with close relationships established between different elements of the processing system. Correlations between the input tasks (including the accent tasks) and speech output tasks failed to reach significance in this analysis, though this may be due to the smaller subset of children used, as significant correlations between input and output were found in Chapter 9. Nonetheless, some significant correlations were obtained between the Glaswegian condition of the accent auditory lexical decision task and other speech input measures, showing that relationships do exist between 'phonetic discrimination' and other levels. The results of this chapter thus propose that the dimension of variability should also be considered within this interactive system.

Although it was acknowledged that the child's lexical knowledge (e.g. size of vocabulary) might influence performance on the accent auditory lexical decision tasks, interpretation of the results has emphasised the role of 'bottom-up' auditory factors rather than 'top-down' lexical factors in accounting for the poorer performance of the children with speech disorders. This is because the children with speech disorders showed a specific deficit in the unfamiliar accent condition. If lexical knowledge had been the key factor, a depressed performance on the 'own accent' condition would have been expected. At the same time, it has been noted that the children in the speech disordered group had depressed language scores, including scores on lexical measures. On the basis of this task, it is not possible to tell whether this is merely a correlation, or whether there is a causal relationship between poor accent processing and slow lexical development. For instance, we might speculate that the poor auditory abilities of these children, which include depressed ability to process variant input forms of lexical items, (e.g. when the word is spoken in an unfamiliar accent), could lead to weak lexical development. However, evidence from the larger sample does not support a strong relationship between input skills and lexical development. Moderate correlations between an input composite and measures of vocabulary (BPVS and Naming) for the speech disordered group were reported in Chapter 9. The regressions did not find a significant predictive role of input skills at T1 in expressive language skill at T2.

Finally, the performance of the controls merits comment. There was no difference in their performance on the unfamiliar accent compared to their own accent. This result suggests that normally developing children aged 5 and 6 are capable of interpreting accent-related variation accurately. At first sight this appears at odds with the earlier findings, summarised in the introduction to this chapter, that children in the age range 4-9 have difficulties with an unfamiliar accent (Nathan et al., 1998; Pate, 1998; Collins, 1998). The accents selected were the same, preceding stories were also given and the items used in this task were a subset of the words used in the repetition/definition task. The informant used for the Glaswegian condition was also the same as for the other studies (although the London informant was a different speaker). The most likely explanation for the discrepancy in results therefore lies in the task design. In the present study, unlike the earlier studies, pictures were used. The use of pictures undoubtedly makes the task much easier because it reduces the lexical search needed: the child simply has to compare the stimulus to their lexical representation of the picture presented. In the repetition/definition task with no pictures, used by Nathan et al. (1998), the child has to conduct a wider lexical search than in the accent auditory lexical decision task, where the choice has been limited by the picture presentation. This resulted in more instances of failed lexical access.

The discrepant results are therefore likely to be attributable to task differences. This highlights how the processing of accent-related variation under experimental conditions interacts with the demands of a particular task. If the demands of the task are low and the possible responses restricted, a normally developing child will be able to overcome any ambiguity. The speech disordered group, however, which was able to process the London condition appropriately, was unable to make such compensations in the Glaswegian condition. Variability therefore seems to have an even greater impact on children with speech difficulties than on normally developing children.

10.5. Summary

This study has highlighted the importance of examining the processing of accent-related variability in children with speech difficulties as well as other aspects of input processing. As this study was limited to the processing of single words and nonwords, it is important to examine how other factors, such as context, might help the child when processing unfamiliar accents, research that is underway (Nathan & Wells, in progress). The study reported in this chapter has shown how subtle difficulties with the processing of accent variation can block lexical access: this is thus an important variable to consider when assessing children's speech processing and language skills both theoretically and clinically.

Chapter 11
Discussion and conclusions

Introduction

There are three main parts to this discussion chapter. Part 1 summarises the evidence for dissociations and associations in the data, and argues that the developing speech processing system, both normal and atypical, is a dynamic and changing one. This calls into question some of the principles and assumptions behind psycholinguistic approaches to the assessment and therapy of developmental speech disorder.

Part 2 examines the factors that mediate normal and atypical speech development. Particularly, evidence for a severity hypothesis is compared with evidence for a pervasiveness hypothesis. By drawing on the longitudinal data from both the speech disordered group and the control group, and using a range of evidence, it is argued that the initial severity of the speech output difficulty is the most important factor in predicting the course of a speech disorder between the ages of 4 and 6 for children with either specific or pervasive speech difficulties. In addition, findings on nonword repetition suggest that these output problems, at least in some children with persisting speech problems, might be related to 'motor programming' problems. Finally, evidence from early speech/language development is discussed to widen the developmental perspective taken on this cohort.

Part 3 discusses the data in the context of wider theoretical approaches to speech disorder and proposes some future directions for further analysis of the dataset as well as suggestions for further studies.

Part 1: Association and dissociation: psycholinguistic perspectives

11.1.1. Psycholinguistic profiling

An examination of the relationship between speech output and speech input skill has been central to this thesis. Several studies were reviewed in Chapter 2 that presented converging evidence of a role for speech input in childhood speech disorder. However, the exact role of speech input was unclear, as not all children with speech difficulties will show speech input deficits. Because group studies do not show a clear-cut deficit of speech input, or a one-to-one relationship between input and output, a psycholinguistic approach, like that advocated by Stackhouse and Wells (1997) is an appealing one. With individual variation at its core, it outlines the complex relationships between input, representations and output that exist within a speech processing system, illustrated by a box-and-arrow model.

Psycholinguistic approaches in general share a key methodological approach, that of task comparison. Through careful design or selection of tasks that differ in their processing demands, it is possible to explicate whether differing processing components or routes exist, or whether these can be selectively impaired. Primarily, this approach reaches its conclusions by identifying dissociations between tasks. Since averaging scores across children could distort such dissociations, this approach has seen most success with case study data. This approach is arguably of clinical value, as one could identify a speech processing deficit based on a dissociative assessment profile (Stackhouse & Wells, 1997; Bryan & Howard, 1992; Hewlett et al., 1998). Such a profile of dissociation allows for the characterisation of a problem in terms of strengths (spared speech processing skill) and weaknesses (impaired processing skills). This profile can inform therapy in a targeted but integrated fashion (Chiat, 1997; Rees, 2001; Waters, 2001).

11.1.2. Profiling by speech output tasks

In addressing the relationship between speech input and speech output, and, in particular, the influence of stored phonological representations on output, comparison of output tasks has been popular (Dodd et al., 1989; Williams & Chiat, 1993; Bryan & Howard, 1992). Tasks of word repetition, nonword repetition and naming have been directly compared. Differing profiles are argued to indicate difficulties with different aspects of speech processing. A better nonword repetition performance compared to word repetition, particularly, is seen to indicate that the locus of difficulty is with stored phonological representations, rather than output skills. In Chapter 8, word and nonword repetition profiles were examined by classifying each child individually according to their profile. This indicated that the majority of children with speech difficulties did not exhibit the kind of representational problem suggested by superior nonword repetition performance.

However, it is questionable that this is the right kind of interpretation even for the minority of children who do exhibit such a discrepancy. First, children with this discrepancy seem to be performing less well on both word and nonword repetition than children with differing profiles (i.e. word/nonword profiles like controls, or a larger discrepancy than normal peers on word/nonword). Rather than indicating a core representational difficulty, poor performance on nonword repetition and still poorer word repetition suggests problems with learning motor programs for new words. This is the same explanation given by Stackhouse and Wells (1997) to children who are actually better at word than nonword repetition. Even the explanation for this type of profile of superior nonword repetition can be questioned, because a comparison of children showing different patterns of performance found different levels of speech severity. On closer examination, it was found that children who had been categorised as showing a greater than expected discrepancy compared to controls on word/nonword repetition were actually showing a word advantage over children with a normal word/nonword profile, as well as children showing superior nonword repetition, rather than a nonword disadvantage. Their nonword performance was not poor relative to these other children. It could be argued that both subgroups with unusual profiles show different degrees of motor programming problems. The larger than expected word/nonword discrepancy may then be a reflection of the relatively better motor programming skills, allowing for more accurate motor programs to be stored.

A difficulty was found on how one should interpret discrepancy analyses such as these. By comparing across children who were subgrouped according to their profiles, this analysis has given insight into how we interpret what is meant by a given discrepancy. Making a judgement about whether word repetition is 'better than', 'worse than' or 'the same as' nonword repetition can take on a different light when children with speech difficulties, showing differing profiles, are directly compared. Children whose nonword repetition is better than word repetition may in fact have an overall poorer performance on both tasks than children showing one of the other patterns of discrepancy. Such comparisons can be made by examination of clinical profiles at a group level and emphasise that, in addition to comparison with normative data, clinical comparison data gives valuable insights (Mitrushina, Boone & D'Elia, 1999). The issues of severity of the speech difficulty and of changing profiles over time, which shed more light on the nature of their speech difficulties, are explored later in this chapter.

Additionally, the way such profiles are defined is crucial. Previously, discrepancies were defined without reference to normally developing patterns of performance. In this study, children were classified according to the normal pattern of discrepancy, revealing that the majority of children with speech difficulties at each testing phase actually had a normal discrepancy profile. Indeed, it was only at T1 that the speech disordered group showed a significantly greater occurrence of differing profiles. This implies that some children presenting with an unusual profile may not in fact be so unusual: given the range of performance in the control group, it is likely that atypical profiles will occur from time to time in both groups. Methodological issues also make the interpretation of these profiles problematic. The two versions of the word/nonword repetition tasks produced different results in terms of who and how many exhibited atypical patterns, showing that profiling is highly dependent on the tasks and the items themselves. Further, since performance changes over time for the control group, it is difficult to be able to identify any stable, atypical patterns over a period of time. Yet it was seen as important to take account of trends in normal development in order to classify error patterns as typical or atypical. Scoring is another issue. Output tasks were scored by percentage of consonants correct, a method not employed in other studies. For example, Vance et al. (1995) scored repetition tasks on whole word accuracy. How one chooses to measure discrepancy (consideration of normal development, and the unit of measurement) could therefore crucially affect results.

Nonetheless, differentiating between atypical, unstable profiles and typical, stable profiles was fruitful. Crucially, examining typical and atypical profiles over time differentiated to some extent children who would have better outcomes or would have persisting speech problems. Children with resolving speech tended to have a more stable and typical profile. Children with persisting speech problems tended to show less stability, moving between profiles, and so they were more likely to show an atypical profile at some point.

11.1.3. Profiling by speech input tasks

According to the method of profiling by speech output tasks, most children with speech difficulties did not have representational problems and, even for those children with better nonword than word repetition, such an explanation would be questionable. A second discrepancy method was undertaken to explore the role of representations in speech development. An analysis of the speech input tasks was carried out to assess whether phonological representations or phonological recognition was selectively impaired. This analysis had the advantage of using input measures that, it could be argued, more directly assessed these input skills than the previous analysis, which used output skills to extrapolate underlying processing skill.

Results from this analysis showed a dissociation: not all children with speech difficulties had input processing difficulties. However, it was not possible to identify more precisely the influence of representations on output skills. There were several reasons for this. First, children showed a changing profile of discrepancy over time. This was partially due to task sensitivity with the AD: picture task being more sensitive at highlighting differences with controls earlier on, while less sensitive later when both groups reached a ceiling level. The AD: ABX task showed a reverse pattern of sensitivity. It is therefore wrong to conclude discrepant processing profiles by comparing tasks that are not matched on their task demands, even if they are matched on item selection. A second factor could be that these input tasks were not designed to reflect the particular output skills of the children, so failing to investigate the relationship between input and output within the child's unique processing system.

11.1.4. Implications of the profiling technique

Discrepancy analyses were unsatisfactory in extrapolating the relationship between input and output processing, whether comparing word and nonword tasks, or comparing input tasks. Some have argued for the need for individually designed assessments of input processing based on a child's output errors (Locke, 1980; Winitz, 1984; Bird & Bishop, 1992; Rees, 2001). However, there is little evidence to suggest that this would uncover a one-to-one relationship between input and output processing. Bird and Bishop (1992) adopted this approach in a group study of children with speech difficulties. They reported a significant correlation of word discrimination with speech severity ($r = .53$), where discrimination tasks were devised using the child's errors. The equivalent task used in this study, the AD: picture task, was also significantly correlated with word repetition at similar levels ($r = .49$ at T1, $r = .44$ at T2, but not significant at T3). In addition, significant correlations were found for the control group ($r = .60$ at T1, $r = .40$ at T2 and $r = .32$ at T3). Thus a more general task, with the exception at T3, was as successful in identifying associations between skills as a task designed with a child's own errors.

In a presentation of a case study using a similar approach to task design as Bird and Bishop, Rees (2001) did not identify a 'core' processing deficit. Instead, different hypotheses were made of differing processing deficits which varied between lexical items. In this approach, a particular processing difficulty is not assumed on the basis of scoring less well overall than a control group on a particular measure. Instead, comparison is made only within the child's own system. Rather than take an overall pattern of scoring poorly on a particular task, correct responses are considered as seriously as incorrect responses for what this means in speech processing terms. Processing deficits are lexical item specific, with presumably a large number of processing deficits possible within one child's speech system. This approach therefore moves away from a notion of a core, underlying deficit.

If a one-to-one relationship cannot be identified with this careful comparison of tasks using a child's own errors, it provides further evidence against a clear-cut relationship between input/representations and output processing. This mirrors normal development: children can show a mismatch between their speech output and representations, and are able to reject their own incorrect forms (Smith, 1973; Dodd, 1975). This normal phenomenon has been the impetus for postulating two-lexicon models of speech development (Bernhardt & Stemberger, 1998).

Different aspects of a child's speech difficulty may be located at different levels of the speech processing system (Stackhouse & Wells, 1997). Examples of this lack of a one-to-one relationship are the case study of Zoe (Stackhouse & Wells, 1993), Rees' description of Robert (Rees, 2001) and the case of Murray (Hewlett et al., 1998) which highlighted a word/nonword profile but only specific to a certain phonological process (fronting). These findings of variable patterns of performance are argued to indicate a highly complex relationship between phonology and underlying speech processing skills. In other words, there is a lack of stability within the system at any time frame. Lack of stability is one of the key trends reported through this longitudinal study, particularly for output skills, and revealed especially when examining speech processing skill at a fine-grained level. Precisely defined, core, underlying speech processing deficits are difficult to identify at one point in time. Over a three-year period, there is little possibility of identifying core deficits, particularly using assessments that are not equally sensitive to each other at different ages.

This analysis of dissociations between components of speech output and speech input through task comparison proved problematic on several counts. Dissociations seem useful in order to argue for the existence of separable processing components or routes. However, if such dissociations are relatively rare (in the case of nonword/word discrepancies) or are extremely unstable over time, one could argue against these levels of processing as clinically useful. In Part 2 of this chapter, it is argued that examining the changing profile rather than a cross-sectional profile, is far more revealing about the nature of these children's difficulties. Assessing specifically to uncover cross-sectional dissociations might be misguided (the usual application of this approach), if the probability of finding dissociations which are both valid and stable is small. Since task sensitivity is such a confounding variable in a task comparison methodology, it may be preferable in a clinical setting to use results from different types of tasks as converging evidence for a general input or output problem rather than more specific deficits because information on specific or pervasive processing problems, and on severity of speech involvement, has prognostic value. It would be better to select tests that show the greatest sensitivity for a particular age group as evidence, for example, for an input problem, rather than compare a sensitive and less sensitive test in order to locate a more specific input deficit. Further, instability within the system might be a good indicator of a more persisting difficulty, as children with continuing difficulties tended to have unstable profiles over time.

Even taking a lexically based approach to assessment and therapy would be problematic (i.e. where different lexical items are targeted in therapy according to the processing difficulty exhibited at the time of assessment). This is because a lexically based analysis of processing deficits is a reflection of lack of stability in a developing speech processing system. Rather than conceptualising that each lexical item or group of items reflects different processing patterns, this dataset would be more compatible with a description of an individual speech processing system as a system in flux. As levels of processing are interactive, and can change in their pattern of interaction over time, and as phonological skills are also developing, one might expect a mismatch in patterns of performance between individual lexical items, and that these mismatches may later change or even be reversed.

Intervention following a psycholinguistic technique of profiling is eclectic, using strengths to compensate weaknesses and focusing on different aspects of the speech processing system (Rees, 2001; Waters, 2001). This approach moves away from a rigid interpretation of the assessment data, and so already incorporates the notion of an interactive processing system. However, an interactive characterisation of a developing system would have further implications for therapy. Rather than a focus on patterns of processing deficit, an understanding of the nature of change and interaction (i.e. how a child acquires speech and language) would be informative in planning intervention, when the therapy goal is to achieve change, a position also advocated in an emergent/connectionist account of SLI (Evans, 2001).

11.1.5. Dissociation of input, output skills and language

Evidence for dissociable skills was found in other analyses. There is very strong evidence to support a more general dissociation between input and output skills and between language and output skills. The speech disordered group was clearly differentiated in whether input/language skills were impaired, and whilst individual measures of this were not stable, an overall pattern did hold over time. Indeed, much more stability was noted over time on proportions of children with associated input problems, or associated language problems, whilst level of speech output skills was less stable during development. If there had been no dissociation between input and output (i.e. all children with speech difficulties also had speech input difficulties) one could argue for a much more unitary kind of speech processing system, where a differentiation of input and output skills is irrelevant, as all children have a general speech processing deficit rather than a speech output difficulty, which is separable from input skills (and similarly for a consideration of language). Such a unitary system would not reflect the patterns of performance observed, i.e. speech output skills, with spared speech input skills.

11.1.6. Exploring dissociation through multivariate analysis

Further evidence for a dissociation of speech processing skills comes from the multiple regression analyses, reported in Chapters 8 and 9. Multiple regression analysis has two functions, which may seem to work in different directions. First, such an analysis looks for associations and relationships between skills, which, when a longitudinal perspective is taken, can lead to hypotheses about causal relationships as well. This is therefore an examination of how skills interact, rather than how they are separable. At the same time, by comparing the relative contribution of two or more predictor variables to another variable, one is hypothesising that the predictor variables may predict different and unique variance in the other variable. In Chapter 8, comparison of the influence of the AD: picture task and AD: ABX task was based on the theoretical assumption that they would predict different and unique variance depending on the output task, i.e. that they were separable and dissociable skills in the relationship they had with other output tasks. In this way, a regression can shed light on both associations and dissociations. Indeed, the two auditory tasks did look as though they were measuring separable skills, though not in the way predicted. Whilst issues were raised about the validity of comparing two tasks that were quite different in their distribution and task demands, it was found that the tasks contributed unique variance in output measures. As these results were neither consistent nor as predicted, it is somewhat unclear what it is about the tasks that are dissociable. With better designed assessments, it might be possible to understand the different processes underlying these two tasks.

Turning to the multiple regressions reported in Chapter 9, more general dissociations between output and input skills were found. These skills predicted unique variance in both later output and input skills, at some time points. These results are analogous to the dissociations found at an individual level, where some children show both input and output difficulties, but other children, with only output problems, are evidence for a dissociation of skills. Input skills at T1 were not uniquely predictive of later output skills at the last step. Input skills at T1 therefore shared variance with output. However, output skills did predict unique variance at the last step, showing that these measures, whilst sharing variance with input, were also tapping into different skills from input processing. If output had not contributed significant unique variance (e.g. if there had been shared variance between input and output), then one could have questioned whether these levels are really dissociable. Dissociation between input and output skills was particularly clear-cut for the control group, where both skills (at T1), when entered at the last step of a multiple regression, predicted significant unique variance in later output skills (at T2 and T3). The composite tasks were therefore measuring different skills, both of which made an important contribution to later output skills.

In summary, there is good evidence for dissociations between speech output and speech input skills from both an examination of clinical profiles and from the multiple regression analyses of normal and atypical development. Evidence for further differentiation between speech input skills is less convincing, though both clinical profiles and the regression analyses did show that they seem to be measuring different underlying skills. The changing clinical profiles make a clear differentiation difficult to ascertain, and invite a more developmental perspective. The regression analyses, some of which were longitudinal, by examining relationships between skills, address development and change directly. However, they do not show that the dissociation found between input levels shares a consistent relationship with output skills.

11.1.7. Exploring association through multivariate analysis

What is the evidence for associations in the data? Evidence of associations is shown in both the clinical profile analyses and the correlations/multiple regressions analyses. Many children did show pervasive speech output and speech input problems, i.e. there was an association between these skills. Correlations found highly significant relationships between output and input processing, in both the speech disordered and the control group. These results show that co-occurrence is relatively common in children with speech difficulties and also indicates that there are relationships between these components of processing in normal development. These associations do not invalidate the dissociations between the tasks as clinical profiles of children's input and output skills clearly demonstrate that output can be selectively impaired. The associations do, however, highlight the interactive quality of these speech processing skills, in contrast to an analysis of dissociations which emphasises separable processing components. The factor analysis reported in Chapter 9, which showed speech processing skills loading on just one factor, is also evidence for a greater emphasis on association and interaction of levels within a speech processing system, rather than on dissociation. Additionally, particularly for the control group, the differentiable skills of input and output (at T1) are both uniquely predictive of later speech output skills: the speech processing system may be dissociated by input and output, but these dissociated skills are both associated with later speech development.

Rather than treat the instability of processing skill as a theoretical problem, it can be argued that the inter-correlations at one time phase and between time phases indicate a system in flux, where different aspects of this system are developing in a dynamic way. This period of development can also be treated as a period of continuous rather than discontinuous change. There is some evidence of changing predictors and changing degrees of relationship that could show development of a discontinuous nature. However, some variation is expected from error, and also from the imperfections of the instruments used. For the control group, there was also a plateauing in speech development, reflected in ceiling effects, so that changes in relationships between tasks are not firm evidence for new stages or phases of development. As children's skills were measured at one-year intervals, further exploration of changing skills at shorter time intervals is needed to understand more fully the manner of change in the system.

The regression analyses thus show associations between aspects of the speech processing system, which characterise the system as a dynamic and changing one. The role of input skills in the development of speech output skills also raises the possibility of a causal relationship between input and later output skills. In cognitive neuropsychological terms, this could be termed a downstream effect of input skills in later output skills, for both children with speech difficulties and normally developing children. Section 2 discusses whether such a *causal* role for speech input is plausible or whether the speech processing system is better characterised as *interactive*. Teasing apart the role of output and input skills, which are so closely enmeshed in a system that is developing and changing, will perhaps remain an elusive goal. Interactive development can be explained better using connectionist terminology than through static cognitive neuropsychology or psycholinguistic models. Learning is described through the relationships between variables: learning occurs through interactions of processing units, with change emerging through shifts in the strengths of connections between units through exposure to stimuli (Elman et al., 1998). Connectionist accounts thus describe mechanisms of change.

11.1.8. Converging evidence from examination of associations and dissociations

Consideration of associations between skills has been an extremely fruitful exercise in understanding the developing speech processing system. In a way that is compatible with a study of dissociations, a more complete picture of speech processing skills in normal and disordered development has emerged. This analysis is thus in keeping with some of the psycholinguistic principles advocated by Stackhouse and Wells (1997). They have advocated broadening the way in which speech difficulties are described and assessed, by looking beyond surface speech characteristics, to examine input and output processing and representations. A more analytical approach to task selection, assessment and interpretation has also been emphasised in the clinical application of these principles. Only through a study of dissociations and an analysis of unique patterns and profiles of performance can one identify subcomponents of the speech processing system.

The examination of speech variability in Chapter 10 is an example of extending the study of speech input processing, by looking at dissociations and associations of components of this system. Since dissociations do exist (more common ones, like between input and output, as identified here; or, less common ones, like superior nonword repetition (Bryan & Howard, 1992; Hewlett et al., 1998)) such subcomponents can be identified and described. Quantifying the occurrence of such clinical profiles (and their stability over time) by studying patterns across a sample of the population is also important in order to assess the clinical value of profiling. But, importantly, through a study of associations, the *relationships* between subcomponents can also be described. The relative importance of the subcomponents within the system can be assessed and their role in terms of the development of the system can be tracked. This discussion of associations and dissociations will be extended in Part 2, to examine which factors are central to both normal and atypical speech development and whether the heterogeneity of the sample in terms of presenting profile and outcome can be accounted for by a single explanation of deficit.

Part 2: Course of speech development and causes of speech difficulties

11.2.1. The course of normal speech development

An advantage of using a matched-pairs control design within the longitudinal study is that one can track the normal development of speech processing skills, as well as the pattern of development taken by children with speech difficulties. Comparing performance between groups at one age can establish whether differences or deficits might exist, for example, in input processing, but such a finding does not inform questions of further development or causation. Comparing these patterns longitudinally allows consideration of two developmental factors. First, one can consider whether rate of change is similar for both groups, or whether presenting deficits will result in differences in rate of development. Second, it allows exploration of the effects of certain skills on the development of later skills and whether the relationships between these skills follow similar patterns in both groups, i.e. whether relationships between skills are similar, delayed or disordered. Consideration of these two factors may also allow hypotheses to be formed not only about the course of a speech disorder within the time frame measured, but also about the cause of speech difficulties.

11.2.1.*1*. Rate of speech/language development

In terms of speech output development, it was found that normally developing children attained near perfect scores on speech output tasks (except for nonword repetition) by T2 and T3, i.e. skills associated with output are well developed. Little change was noted between T2 and T3, a plateau in scores which reflected high levels of accuracy on these tasks. Since these tasks included long and complex items, it was concluded that the tasks were sufficiently challenging to capture a genuine plateau rather than simply a ceiling effect due to a task which lacked items capable of measuring these skills.

Further improvement was noted on nonword repetition. This result suggests that whilst the high level of performance from other speech output measures rules out continued articulatory development, skills involved in repeating unfamiliar phonological material are still developing. The skill of repeating nonwords may involve input processing (Dollaghan, Biber & Campbell, 1995; Ceponiene, Service, Kurjenluoma, Cheour & Naeaetaenen, 1999). Certainly, continued development of speech input skills was noted between T1 and T3 in normal development. Whilst input skills were sufficient to support very accurate word repetition performance, it is hypothesised that they may not be sufficiently developed to support the repetition of unfamiliar and complex phonological material with a very high degree of accuracy. This is corroborated by the analyses of relationships between variables reported in the next section. Alternatively, the skills of motor programming may continue to develop, revealed in lower performance on nonword repetition than word repetition.

Lastly, language skills continued at a more even rate of development. Lack of change was noted on RAPT, but on the other tests that were standardised on a large range of ages, continued improvement was noted.

11.2.1.2. Relationships between speech processing and language skills

From the series of multiple regressions reported in Chapters 8 and 9, an important role for speech input in the normal development of speech output was established. Conversely, speech output was not predictive of later speech input skills (except in one case, AD: ABX at T3, but this task was subject to ceiling effects, so the result is not interpretable). In general, output skills uniquely predicted later output skills, an autoregressive effect. Input skills, after controlling for this autoregressor, uniquely predicted later speech skills, showing a very important role of input processing in speech development. In the case of nonword repetition at T3, T1 speech output skills were not uniquely predictive, where speech input skills were, suggesting that the ability to repeat unfamiliar phonological stimuli can be related more strongly to input than output processing.

An examination of the role of expressive and receptive language skill in later speech output processing did not find language skills predicting unique variance in later speech skills, though there were significant correlations between measures of language and speech output and speech input. Nonverbal ability and age were also found to predict later speech skills. Age reflects the role of maturational effects, and nonverbal ability that of more general developmental skills.

The particular role of speech input could reflect a more direct causal relationship between input and later output skills. However, this statement needs some qualification. Relationships between the measures of the test battery reflect an interactive system. Also the role of maturational effects and nonverbal ability place the development of speech skills in the context of a child's general development, rather than a dissociable skill, mainly or only influenced by an earlier skill. Nonetheless, identifying a causal influence for speech input skills in normal speech output is an important contribution of this work.

11.2.2. The course of atypical speech development

Turning to the speech disordered group, it is now possible to describe this group's speech development, in terms of their rate of change and in terms of predictors of development, particularly, focusing on whether these factors differentiate resolved and persisting speech outcome. First, the relationships between skills are addressed.

11.2.2.1. Interactive system or downstream effect of input deficits?

Input skills clearly predicted later speech output skills in the control group. Since input skills thus play a causal role in normal development and some children with speech difficulties had deficits on input skills compared to controls, one could hypothesise that input deficits cause speech output deficits. There are several reasons why this hypothesis needs qualification. First, the causal role in normal development may be mediated by other relationships, including nonverbal ability and maturational factors. Uncovering downstream effects is notoriously difficult in developmental research and some developmental researchers would advocate an interactionist approach as a more plausible account of development (Karmiloff-Smith, 1998). In order to establish a true causal relationship, one would need to recruit participants as infants, before the onset of speech. Second, the multiple regressions that looked at the speech disordered group's development uncovered different patterns of relationships compared to the control group. Speech input did predict similar amounts of variance for the speech disordered group as the control group, when entered before speech output into the regression. However, at T1, when the effect of speech output was controlled for, speech input was found not to be uniquely predictive of later speech output. There was still a unique role for speech input at T2 for T3 speech output, so, although the predictive role of speech input was less strong than for the control group, it still played a role.

Two other differences from controls were noted. Expressive language skill predicted some unique variance in later speech output skills, after controlling for the effects of speech output. Thus, expressive language ability played an important role in the later development of speech in atypical development, and this could not be solely attributed to the speech output deficit affecting ability to mark aspects of language (e.g. syntactic or morphological markers) as expressive language was predictive after controlling for variance associated with speech output skills. Also, speech output skills at T1 were found to predict the development of speech input skills (AD: picture at T2 and AD: ABX at T3). Whilst these other relationships did not hold at all testing phases, these different patterns of results compared to the control group, including this reciprocal relationship, suggest an interaction of speech processing and language skills over time, rather than a downstream effect of speech input. The relationship between output and input processing is interactive both concurrently and over the course of development between the ages of four and six.

11.2.2.2. Pervasiveness or severity?

The notion of an interaction of skills is reflected in the finding that some children with speech difficulties present with pervasive problems, with deficits in input, output and language, and that these difficulties tend to persist. The profile of these children suggests that the development of speech goes in tandem with the development of language skills, i.e. a delayed pattern of skills. Rather than pinpoint input skills as causing output problems (as an interpretation based solely on the control data might have lead one to hypothesise), a system characterised by interaction would be consistent with the occurrence of pervasive profiles.

However, some children with persisting speech problems show a dissociation between their speech output deficit and other intact speech/language skills, which might be a problem for an interactionist account of speech development as, for these children, the speech processing system is selectively impaired. Further, the regressions show that the development of speech output skills is heavily influenced by the speech output disorder itself, which might lead one to consider the extent or severity of the speech output deficit as crucial in describing changes over time. Indeed, it is the greater role of speech output in predicting input skills (as well as language skills) that makes the speech disordered data look more interactive than the control data. Although pervasiveness and severity are related, with children with more severe speech problems likely to have more pervasive problems, it is important to try and establish whether it is a severity or pervasiveness continuum that drives atypical speech development. This distinction is an important one because a pervasive problem suggests a more general speech processing problem predicted from an interactive system and reflecting a delayed pattern of development. Speech severity, however, suggests a deficit confined to output processing. Whilst an interactive processing system may be part of speech development, a severity hypothesis would suggest a speech output deficit, dissociated from the rest of the speech processing system, is driving disordered development. The manner and rate of change could inform the issue of whether pervasive problems or severe speech problems are most characteristic of atypical speech development and is explored in the next section.

11.2.2.3. Rate of speech development

Delay during development can be overcome in two ways: either through an accelerated growth rate, or through a decelerated growth rate in normal development allowing others to 'catch up'. The latter appears to be occurring to a certain extent, as normally developing children's speech development starts to plateau after T1, allowing 'gains' to be made by the speech disordered group. Children with resolved difficulties, who had less severe difficulties, reach level with normal development first. Others with more severe initial difficulties may only 'catch up' after further time has elapsed, if they continue to make progress, whilst the resolved subgroup and controls' progress has slowed (with the exception of nonword repetition between T2 and T3 which is discussed below). One might predict that language deficits will become a more prominent difficulty than speech skills in the children with persisting and pervasive problems, as normal language development, unlike speech development, will not be plateauing, allowing no catching up to occur. Language skills, particularly vocabulary (as measured by BPVS and Naming) and aspects of receptive grammar (as measured by TROG) continue to develop through childhood. There is some evidence for this: children in the two speech outcome subgroups became more differentiated in their language skills at T3, and notably significant differences emerged on the two receptive language measures.

Thus slower speech development is ruled out because children with persisting speech difficulties are not slower than controls or those whose problems resolve. Indeed, as these children reach high levels of accuracy, children with persisting speech difficulties continue to make progress (except on nonword repetition) and so are able to lessen the gap in performance. Speech outcome is not related to a slower rate of development or a plateau of skills that might be suggested from a critical age hypothesis, where speech skills develop in the first five years of life.

An interactionist hypothesis would have predicted a different developmental course. One could make two predictions in relation to the course of speech and language development. First, one could predict that children with speech difficulties that persist are likely to show more pervasive problems over time, as deficits in speech skill might affect the further development of input skills or language skills (the effect of speech output on expressive language has often been proposed to account for these co-occurring problems). Second, one might predict that children with specific speech difficulties might utilise their intact language and input skills to create an accelerated pattern of development compared to those children with more pervasive problems, and so resolve their speech difficulties.

Some children with specific speech difficulties do develop more pervasive problems later on, and this would serve as evidence that the output problem can become a wider speech processing problem. However, other children with specific problems continue to have specific and persisting problems. If the system is highly interactive, there is a challenge to explain why these children with specific speech output difficulties do not necessarily develop more pervasive speech processing/language difficulties over time, as the disordered system engages in interactive development. Why does a dissociated difficulty not become a more pervasive problem?

In order to answer the question we turn to the issue of resolving difficulties and ask the question: why do many children with this profile normalise? One could argue that children with specific speech difficulties have a better speech outcome because their other processing skills are intact, which helps them compensate. This would be an erroneous assumption because children with specific difficulties do not follow an accelerated pattern of development compared to those with pervasive and persisting problems. The retrospective analysis showed that children with specific speech problems actually have initially less severe speech difficulties, so they normalise having started off at an advantage. Children with pervasive problems do not normalise at the same point, not because they have pervasive problems that cause a spiral of deficit, but because their speech difficulties were more severe initially. Evidence for a 'Matthew effect', where those with better skills earlier do even better, and those with poorer skills score progressively less well (i.e. as might be predicted from an interactionist view of development), was not found. There was no evidence that the persisting speech group was slower in its development of speech input, language measures or nonverbal measures compared to the resolved speech subgroup. A difference was noted at T3 on the nonverbal measure of Picture completion between the persisting subgroup and their formally matched controls. This could be seen as evidence of a Matthew effect in general abilities and confirms findings of a small Matthew effect obtained by Shaywitz, Holford, Holahan et al. (1995) for children with reading difficulties on an IQ task, which also used a longitudinal methodology.

Severity of speech skills (measured at T1) is proposed to account for change in children with speech difficulties. Variance in early input skills and language measures do contribute to the development of later speech output skills, in a similar way as occurs in normal development, but these skills often share variance with output skills, whilst speech output predicts unique variance in later output skills after controlling for these other skills. Despite different levels of performance, standard deviations show that there is a similar degree of variance on speech input and language measures in both normal and atypical development. This finding, together with the evidence from the regressions, suggests a similar role of these skills in atypical development. It also explains why speech difficulties can be associated with language difficulties. Depressed scores in these areas will be associated with depressed scores on speech output and this pattern is likely to continue over time. However, the predictive role of speech output swamps these influences. For speech output measures, speech output accounts for much larger amounts of variance in the speech disordered group than the control group, reflected in the larger standard deviations of the speech disordered group, and the larger R^2 value when speech output was entered at the last step. This variance reflects the greater range of speech output performance in the speech disordered group. The variance is greater because of the large range of speech output deficit. It is this variance, i.e. these ranges of speech severity, that best predict later speech performance, rather than poor input skills, which would indicate a pervasive problem.

Further evidence for a speech severity hypothesis comes from the children with specific speech output problems whose problems persisted. Their speech output deficit looks more severe throughout than children in the resolved speech subgroup. By T3, their specific speech output problems had not resolved, showing that persisting problems can occur in isolation from pervasive problems. But their speech output problems are less severe at T1 than for the children who have both pervasive and persisting problems, i.e. speech output difficulty of the specific, persisting subgroup is moderate. It will not resolve at the same point as those with the milder speech output difficulties that resolved by T3, but it will be closer to that point than for those children with pervasive problems.

The answer to why a *dissociated* difficulty does not necessarily become a pervasive difficulty also lies in the severity of the initial speech difficulty. As children with specific speech output difficulties have relatively mild/moderate initial speech difficulties, little negative impact seems to be made on the processing system. The mismatch between input and output is slight, because output skills are not so severely impaired, therefore creating little disturbance in the rest of the system. The output skills are adequate enough to sustain a continued, non-impaired speech input system, and indeed the output problem resolves in the course of development. When there is a slightly more severe initial speech difficulty, the rest of the speech system may still be spared, but the problem will only resolve at a later stage because the initial delay was greater (though see below for hypotheses about the children's further speech development). More massive deficits in speech output are related to more pervasive difficulties (already existing at T1, rather than later emerging), with problems not resolving in the short term.

11.2.3. The nature of the difficulty

The last section argued that speech output mediates change within the speech processing system. Other skills also played a role, and development was seen as interactive, but with initial speech severity determining the course of a difficulty and when it will resolve.

This leads to two questions. First, taking the role of speech severity as key in speech development, should we consider this population to have a primary speech output difficulty, even though many of the children could also be accurately described as having a speech processing difficulty or having speech and language difficulties? Following from this, can speech severity account for the heterogeneity of the cohort, in terms of their varying speech processing and language skills, and in terms of their varying outcomes? Or do the differing presenting profiles of children with specific speech problems and children with speech and language difficulties reflect two different disorders?

It is possible to argue that the origin of pervasive difficulties is in some kind of core processing deficit very early in development (pre-T1), and that the relationship between severity and pervasiveness is an indistinguishable one in these cases. Further development is then mediated by severity, with widespread difficulties already setting a developmental trajectory of delayed processing. Since the speech processing system is likely to be even more interactive at an earlier stage of development, this is a plausible rationale for initial onset. This is to argue for three original types of deficit: a core processing deficit for those with pervasive problems, a core output problem for those with specific output problems, and a delayed pattern of development with mild speech problems that resolve early on. This latter profile of the resolved speech subgroup could be considered as falling within the lower end of the normal range.

Despite two presenting types of persisting deficit, one explanation - that of speech severity - is sufficient to explain outcome within this dataset. Heterogeneity of speech development is uniformly accounted for by speech output (as shown in the multiple regressions by the unique and substantial variance of early output skills on later output skills). The less severe speech problems of the resolved speech subgroup show that severity also can account for these children's better outcomes. Heterogeneity of speech/language profile for children with persisting speech problems could also be hypothesised to be the result of one type of speech output impairment. More generalised involvement stems from reaching a certain threshold of severity. Such an account would be consistent with those who argue that generalised difficulties might emerge from a modular problem (Frith & Happé, 1998). It could also be compatible with a mapping theory that locates children's language difficulties in a faulty mapping between sound and meaning (Chiat, 2001). If the child's sound system, or, according to the argument developed later in this chapter, motor programming skills are sufficiently impaired, the mapping process will also be disrupted. A less severe speech deficit, on the other hand, might not disrupt the mapping process, leaving language skills intact.

Whilst differentiating pervasive from specific difficulties might be useful clinically in terms of presenting profiles, this differentiation does not reliably predict outcome, as children with both these types of profile may have persisting profiles. Theoretically, it would be more elegant to propose a unitary explanation of speech severity for the two profiles, an explanation that accounts for variance in presenting profile and variance in further development and outcome for those with persisting speech problems.

If severity of initial speech output difficulty were the sole factor that determined further development, one would expect that, not only does it determine who has resolved by T3, but also at what later point a persisting problem will resolve. This would assume that it is a question of time before children 'catch up' with those whose speech skills have already resolved. However, there is evidence from nonword repetition development that this may not be the case for all children, as nonword repetition fails to improve significantly, indicating that, for some children with persisting problems, nonword repetition skill is reaching a plateau. Thus it may be important to explore an hypothesis for these children beyond that of severity. The next section argues that motor programming deficits may account for this pattern of performance.

11.2.4. Changes in nonword repetition as a marker of a core, persisting difficulty

For children with persisting speech difficulties, nonword repetition between T2 and T3 does not improve at the same rate as word repetition. This is a reverse pattern to the normally developing controls who have plateaued on word repetition, but make significant progress on nonword repetition between T2 and T3. It is therefore uncertain whether children in the persisting speech subgroup will continue to make progress and whether they will ever resolve fully. Indeed, for children with specific persisting speech problems, and children with the most pervasive speech difficulties, nonword repetition performance does not significantly improve between T2 and T3. The number of cases was small, but nonparametric statistics showed no significant change between T2 and T3 for a subgroup of eight children with specific, persisting problems and a subgroup of eight with the most pervasive, persisting problems. The increasing discrepancy was apparent across the entire persisting subgroup. However, there are some children within this subgroup whose nonword repetition performance does improve significantly. Children who are making gains on nonword repetition may have a better prognosis and be similar to those children whose speech problems have already resolved. Rather than a specific motor programming difficulty, as is hypothesised for the group of eight with specific, persisting problems, these children may have a more general type of speech and language delay. Again, this could be hypothesised to be in contrast to the pervasive and persisting subgroup of 8, who, with both speech and language disorder, are also argued to display motor programming deficits. Alternatively, word/nonword differences may emerge at a later stage. But, because of their continuing progress on nonword repetition, the following proposal of motor program difficulties would need to be corroborated for some children with persisting speech problems, by further follow-up.

To interpret the finding, we return to the interactionist debate. Whilst a general cycle of deficit has not been supported, interpretation of this word/nonword finding leads us back to a discussion of the way input may impact selectively on nonword repetition, at least for those children with pervasive difficulties.

Poor nonword repetition has been cited as evidence for difficulty in creating new motor programs (Stackhouse & Wells, 1997), poor phonological short term memory (Gathercole & Baddeley, 1990), slower lexical development (Gathercole, Willis, Baddeley & Emslie, 1994) and has been identified as a genetic marker of SLI (Bishop, North & Donlan, 1996). Nonword repetition has also been linked with perceptual processing skills (Dollaghan, Biber & Campbell, 1995; Ceponiene, Service, Kurjenluoma, Cheour & Naeaetaenen, 1999) and the role of output skills has also been recognised (Gathercole et al., 1994; Hulme & Snowling, 1992). Since the children in this study have/had speech output difficulties, and development of these output skills was strongly correlated to previous output skills, there is little reason for a phonological short term memory deficit to be cited as their core deficit. In the study of children with SLI, where the role of phonology has been considered to be less central, there is consequently more debate over the exact explanation for why children show poor nonword repetition (Gathercole, 1995; Edwards & Lahey, 1998; Sahlen, Reuterskiold-Wagner, Nettelbladt & Radeborg, 1999; Vance, 2001).

It could be argued that an input processing deficit is related to poor nonword repetition because some children in this cohort do have input processing difficulties. Additionally, input processing is strongly predictive of nonword repetition in the control group. Input at T1 predicts unique variance in T3 nonword repetition, whereas T1 output predicts no unique variance. Therefore input skills are related to nonword repetition in normal development. Poor input skills could thus impact on a child's ability to repeat unfamiliar phonological material to a greater extent than the repetition of familiar phonological material, hence the emerging discrepancy between word and nonword repetition observed at T3. As nonword repetition is analogous to new word learning, ? further progress in speech development, which occurs in the context of vocabulary growth, could be hampered, and input problems might contribute to this continued difficulty (language difficulties including vocabulary problems were observed in some children).

However, this explanation is flawed in the same way that the more general argument for input skills being causally related to output skills is. The explanation cannot account for the group of eight children with isolated speech difficulties, who had no input deficits but did show the same word/nonword pattern. These children have difficulty creating accurate new/temporary motor programs (i.e. nonword repetition fails to keep pace with word repetition), but there seems to be no knock-on effect of earlier or concurrent input difficulties. Instead, these children show a dissociable output problem, or more specifically, an hypothesised 'motor programming' difficulty. The especial difficulty with nonword repetition suggests a problem with a level of speech output that is not simply at an articulatory level. One would not expect a lower-level articulatory problem to have a differential effect on word and nonword repetition. A problem at the level of motor execution would result in a similar level of performance across tasks, with the degree of discrepancy encountered in the normal population. A study of nonword repetition looking at children with language impairments found that nonword repetition did not correlate with oral motor status (Sahlen, Reuterskold-Wagner, Nettelbladt & Radeborg, 1999). Thus deficits in nonword repetition are located between stored representations and lower level articulatory skills. Stackhouse and Wells (1997) would call this a difficulty with 'motor programming'. It has also been called 'articulatory planning' (Chiat, 2000) and an 'articulatory planning mechanism' (Hulme & Snowling, 1992). By extension, the problem is hypothesised to affect the level of the motor program (Stackhouse & Wells, 1997) or output phonology/the lexical articulatory system (Hulme & Snowling, 1992). A problem with motor programming would lead to a difficulty in establishing accurate motor programs as new words are learned (Hulme & Snowling, 1992). With practice, these motor programs become more accurate, but the deficit in motor programming is illustrated by continuing difficulty with new or unfamiliar phonological material. This explanation shows how children have difficulties with both words and nonwords, but, with experience, word repetition improves whilst nonword repetition continues to be problematic.

The finding that the AD: picture task (at times) predicted concurrent and longitudinal variance in nonword repetition for both groups (though AD: ABX was more predictive for the speech disordered group) is of relevance here. This result was interpreted as indicating that representational levels might indeed be involved in processing unfamiliar stimuli and that there are close associations between phonological storage and other phonological processes (Snowling, Chiat & Hulme, 1991). Alternatively, motor programming skills, rather than an individual stored motor program, might be the main way that stimuli, whether words or nonwords, are processed. The processing of words also calls on stored representations, and some kind of practised articulatory routine, which allows for superior word repetition in relation to nonword repetition. The model proposed by Hewlett et al. (1998) does not have stored motor programs, but a "*collection of articulatory routines*" (p.172), a concept which might be more consistent with this result.

Whilst interpretation of the relationship between AD: picture task and nonword repetition must remain tentative, the finding of an increasing discrepancy between word and nonword repetition allows some stronger hypotheses to be proposed. By arguing for a motor programming deficit, the notion of a pervasive speech processing deficit is rejected, as these children have specific speech output difficulties. These children have a speech output difficulty the severity of which influences the time at which the problem resolves. Such an output explanation is also sufficient to explain the performance of children with the most pervasive problems. It is unnecessary to argue for a special role of input in nonword repetition for these children. Their speech output skills are more severely impaired than those children with specific and persisting speech difficulties. It is therefore likely that the role of output (which includes motor programming) could be even greater for these children. It is not necessary to claim that it is the speech input skills that cause this greater severity, as it has been established that the speech processing system is highly interactive. Although input skills do share a relationship with nonword repetition, output skills are predominant, and more severe speech difficulties are likely to be associated with more pervasive problems. With growing accuracy on word repetition (and plateauing normal development on this task), the deficits of children with pervasive difficulties at T3 are more apparent on nonword repetition than word repetition, hence the emerging discrepancy. This evidence only emerges later in development and does not stem from identification of specific word/nonword discrepancies at any one time point. Instead, evidence is cited from the changing pattern of performance between these tasks over a three-year time period.

The word/nonword pattern has been identified through comparison with the normally developing pattern of these skills and through comparison of this pattern in children with speech difficulties whose problems resolve. Some children's lack of improvement on nonword repetition between T2 and T3 is also observed through examining individual or subgroup performance of a smaller subset, rather than through cross-child comparison. Thus developmental patterns are found through actual and relative performance. It has been difficult to uncover specific underlying processing deficits in children with speech difficulties due to the interactive nature of speech processing skills. However, by examining the *changing* nature and pattern of performance on speech processing tasks, one can present another argument to support the hypothesis that speech output processing is the central disorder. First, it was argued that severity of the initial speech output difficulty mediates speech and language development. Further, it was proposed that these speech output difficulties were likely to be difficulties of motor programming. Both children with specific and pervasive persisting problems showed similar developmental patterns on nonword repetition, and a motor programming difficulty was hypothesised. However, they differed in the extent of absolute level of performance, hence a differentiation on the severity of the problem.

One can hypothesise that this change in repetition pattern over time shows that this disorder may not be a transitory one. If this is the case, lack of change in nonword repetition, in relation to a matched word repetition task, is a marker of an intransigent core motor programming deficit. A nonword repetition task thus reveals a persisting deficit, at an age when children continue to learn to produce familiar words more accurately. Indeed, evidence of persisting deficits on nonword repetition would add validity to this argument of motor progamming difficulties. Nonword repetition has been cited as a genetic marker of SLI (Bishop, North & Donlan, 1996), i.e. as an indicator of a persisting underlying language deficit, when other problems have seemingly resolved. This analysis also shows how studying development of word/nonword performance can be informative of the core nature of a speech deficit. Follow-up of this cohort will bear out whether or to what extent such a core deficit is still evident.

11.2.5. Delayed onset of speech?

The role of severity has been outlined and the key factor of motor programming difficulties has been identified through emerging patterns of performance on nonword repetition. This evidence starts to account for why and how they might recover or fail to recover from initial speech output difficulties. However, the results do not account for how or why these problems develop initially. Nevertheless, one can hypothesise about earlier development, before T1.

Children with persisting speech problems are reported to be later in saying their first words than normally developing controls (an average of 9 months later). If this is taken to indicate delayed onset of speech/language skills, this could account for their delayed pattern of speech/language development. It confirms findings of a relationship between late talking and delayed speech (Paul & Jennings, 1992; Mirak & Rescorla, 1998). Since, during the course of the study, with the exception of nonword repetition, children's difficulties were not found to be related to arrested or slow development, delayed initial onset is a plausible explanation for their delayed pattern of performance.

However, these children present with severely impaired speech output difficulties, rather than speech skills that are equivalent to a child who is nine months younger. One might want to argue therefore that output skills, or, more specifically, the motor programming problems (identified at a later point in development) rather than delayed onset is the core explanation for their presenting difficulties and that these difficulties cause the delayed onset of speech. If these problems are severe, problems of a more pervasive nature will also emerge (as previously argued for later development). Another perspective is also possible. The finding of later reported onset of first words might not reflect actual onset, but might be measuring when a parent observes a child's first *recognisable* words. As these children have significant speech output problems /motor programming difficulties, first attempted words are likely to be unintelligible/ uninterpretable. In this case, the finding is simply a measure of speech difficulty, rather than delayed onset.

Children with resolving speech difficulties are not significantly different to controls on reported age of first words, an average 5.6 months later than controls. This nonsignificant later onset may indicate these children are at the lower end of the spectrum of normal variation. *Statistical* significance on the Edinburgh Articulation Test is not necessarily reflective of a *clinically* significant speech disorder. A clinically significant speech disorder could best be defined as a core severe speech output difficulty that is likely to persist. For certain reasons – whether social conventions or from a perceived sense of what is normal – these children are labelled as having a disordered behaviour, or, are referred to speech and language therapy services because of individual circumstances (e.g. a child may be referred to therapy due to parental concern). In other words these are children who have a transitory problem or delay rather than a clinically significant speech disorder. They do not have a specific motor programming deficit and their apparent difficulties have resolved by T2. Phonological analysis of the cohort's speech might also indicate differences in the type of speech errors encountered depending on whether a child has a persisting or resolving speech profile, in a way advocated by Dodd (1995) who subgroups children on the basis of, amongst other variables, delayed or deviant phonological patterns.

Part 3: Wider theoretical contexts: making connections and future directions

11.3.1. Motor programming

Locating persisting speech difficulty as an output deficit and as a possible motor programming deficit, connects with the literature on motor programming/ motor planning difficulties. Whilst this is a complex literature, some brief comments will be made here. Children in this study were not labelled as dyspraxic because diagnosis of developmental verbal dyspraxia is difficult to make, the area is controversial (Crary, 1993; Ozanne, 1995; Shriberg, Aram & Kwiatkowski, 1997) and the aim of this study was to examine a broad range of developmental speech disorder. Ozanne (1995) finds differential diagnosis complicated by the fact that children identified with dyspraxia usually have severe speech disorders when one might expect a range of severity. When a child's speech difficulties improve over time, a milder presentation of difficulties could be seen as no longer dyspraxic in character (Ozanne, 1995).

Developmental verbal dyspraxia is usually diagnosed by looking for clusters of deficits in speech output performance (Stackhouse, 1992). Thus the psycholinguistic approach of task comparison evaluated here is different from assessment of clinical features of motor speech performance. Nonetheless, it is likely that some children in this study could have been labelled dyspraxic, according to such features. If this is the case, nonword repetition performance between T2 and T3, which, it is argued, reflects motor programming problems, might be converging evidence for this type of problem. These children are the ones with the persisting speech problems, and thus the children with the most severe speech problems in the cohort. However, their level of severity is defined in relation to those whose problems resolve later. Therefore it is not in all cases comparable to the levels of severity Ozanne (1995) implies is associated with a diagnosis of dyspraxia. Motor programming has been examined here through a psycholinguistic procedure of task comparison which explores changes in patterns of performance within one child's system, but also takes account of normal development. This has allowed more subtle motor programming deficits to be identified, and hence, not just an identification of children with the most severe deficits.

Work by Bradford and Dodd (1994, 1996) has used tests of novel word learning to investigate the motor speech skills of children with speech difficulties including those with developmental verbal dyspraxia. One of the strengths of these studies is to have compared novel word learning with other motor planning tasks including diadochokinetic rates. Their interpretation of their findings runs counter to the arguments presented in this chapter. Bradford and Dodd argue for different subgroups of children, defined by their surface speech characteristics, and validated by differing performance on motor planning tasks. This is in contrast to the present proposal that speech severity accounts for heterogeneity without the need for rigid subgrouping, and, in particular, that motor programming is a core marker of persisting speech difficulties. Several factors may account for these differing interpretations. Bradford and Dodd (1996) did find that their subgroups differed on speech severity (measured by pcc) and the pattern of severity was repeated in their nonword repetition task. A severity hypothesis therefore cannot be ruled out as an explanation for this data. Their study was cross-sectional, but novel word learning was measured across the session, allowing changes to be measured. This did show differences between the subgroups in ability to learn to imitate novel words. However, without a matched word repetition task, and over such a short time span, results are not directly comparable with the data reported in this study. Also the role of language and input skills was not addressed. Another aspect of difference was the inclusion of phonological analyses of the participants, allowing comparison of surface speech characteristics and underlying processing skills (discussed in the next section), which was not attempted in this study.

11.3.2. Phonology

Links are hypothesised between the trends in this data and the literature on some motor speech disorders. The popularity of a phonological approach to speech disorder stemmed from a dissatisfaction with an approach that did not examine phonological patterns of a child's speech and also did not account for the heterogeneity of the population, the majority of whom did not show a clear-cut aetiology. No phonological analysis was conducted in this study, so it is not possible to make direct comparisons between phonological patterns and the psycholinguistic and developmental investigation. It is noteworthy that the study of associations and dissociations of performance on the measures used produced an account of atypical speech development, without the use of a phonological analysis.

11.3.3. A psycholinguistic approach

Phonological analysis is a way of describing surface speech characteristics. Psycholinguistic analysis has been proposed as a way of explaining why certain surface phonological characteristics are present (Stackhouse & Wells, 1997), e.g. that a velar fronting process may be due to a problem with discrimination of /k/ and /t/. However, using some of the principles of this approach in this study, has led to a questioning of a psycholinguistic methodology. Specific core deficits were not stable across time, when employing a task comparison. This was partially due to task design issues, where tasks were not equally sensitive over time and to other tasks over time. This is a problem, not just with this study, but with any attempt to capture core processing problems that are, in essence, developmental. Further, the interactive nature of speech processing makes locating precise deficits not only difficult, but also somewhat at odds with the notion of a changing system.

11.3.4. '*A model of predictive risk*' (Law et al., 2000)

Examining development itself, and how the speech processing system interacts, has been more fruitful. There is a strong clinical motivation for this. A longitudinal approach allows us to look, to some extent, at the 'natural history' of the disorder and so address issues of prediction and outcome. This has not been a true study of 'natural history', as the children were receiving intervention for their difficulties. However, we were able to rule out substantial effects of therapy on outcome, as the patterns of intervention showed children with poorer outcome had generally been receiving more therapy; a therapy advantage did not translate into an outcome advantage. The study may be closer to what Law et al. (2000) term a '*model of predictive risk*'. Such a model aims to inform the process of prognosis through identification of clinical markers of outcome. This study has gone some way to identify these markers. Evaluating children's performance over time, and in comparison with normal development, has also extended our theoretical understanding of the disorder itself. Re-evaluation of speech processing explanations of the disorder has been a particular contribution because the study's methodology allowed a developmental perspective to be taken.

11.3.5. Methodological limitations to the study

An argument has been developed in this chapter that speech output severity, related, in particular, to motor programming skill, plays the greatest role in the further development of the speech disordered group's speech output skills. Despite identifying a role for speech input skills in normal development, an important finding of the study, it was found that when the speech disordered group's performance was examined, speech output skills were the best predictor of later speech output skill. Such conclusions were drawn from a variety of analyses. In particular, the use of multiple regression analysis, a tool for examining individual differences, allowed for the exploration of the role of different skills in the development of a target skill.

However, the explanatory power of any analysis is limited by the quality of the measurements involved. Several methodological limitations are acknowledged in this study. First, the poor reliability of the speech input tasks could have affected the results of the multiple regression analyses. Despite transforming scores using *d prime* in order to control for guessing effects, the poorer reliability, particularly of the AD: ABX task at T1 for the speech disordered group compared to the control group, could have weakened the role that input plays in later disordered speech development.

Whilst much more reliable measures than the speech input tasks, the tasks and measure of speech output limit the extent to which a notion of 'phonology' is addressed. The measure of speech output severity was based on a composite: word and nonword repetition tasks, and articulatory naming. Percentage of consonants correct (pcc) was used as the measure of accuracy. The output tasks were not designed to be comprehensive in terms of English phonology although the repetition tasks were designed to assess a range of phonemes and to target phonemes and clusters that are later developing. The rationale behind the repetition tasks was not so much to examine a child's phonology as to investigate the relationships between components of the speech processing system in both normal and atypical speech development. For example, the influence of the lexicon on repetition performance was examined by comparing word and nonword repetition and examining whether different patterns of performance on these tasks reflect specific speech processing deficits. Stimuli were chosen for their discriminability between groups and over time, and included phonemes and clusters that were more likely to challenge a child's speech processing system. Since one of the aims of the study was to examine normal development, it was also important to create output tasks where normally developing children's speech processing systems would be challenged, partly to allow multivariate analysis to be conducted. However, there are shortcomings to using measures and scoring systems that do not record phonology more directly or comprehensively. Scoring a consonant as accurate or inaccurate, for instance, does not allow one to consider whether type of error is important, as has indeed been acknowledged by Shriberg, Austin, Lewis et al. (1997) in their analysis of their measure of pcc. Errors of distortion, omission or substitution, or errors that are consistent or inconsistent, delayed or deviant in a child's speech, might carry different weightings and influence the development of speech differentially. These different weightings could produce a more complex set of relationships with other skills, such as speech input, that might take forward the more general relationship found between the less precise pcc measure of speech severity and the measures of speech input. Additionally, error analysis could be enlightening when comparing speech performance across matched word and nonword tasks. Whether phonological patterns might be related to speech input performance or to later speech development are therefore important questions for future research. However, they were beyond the scope of this study. Such relationships could not have been examined using multiple regression analysis as error measures of this type would be unlikely to have normally distributed data, especially for the control group, when occurrence of such errors would be negligible.

The lack of unique contribution of input tasks and the overwhelming contribution of speech output skills to the later development of speech output could stem from another methodological issue, that of participant selection. The main criterion for participant selection was the speech output measure of the standardised Edinburgh Articulation Test (Anthony et al., 1970). Whilst age and nonverbal ability were constrained, speech input and language ability were allowed to vary. Thus with speech output as the main defining criterion, it might seem unsurprising that, in the multiple regression analyses, speech output problems appear the dominating influence on later speech development. Whilst pervasiveness and speech severity are difficult to separate (those with more severe speech difficulties also have more pervasive difficulties), the multiple regressions were an attempt to tease apart the relative contributions of different tasks to later developing speech. Given previous research findings (Bishop & Edmundson, 1987b; Johnson et al., 1999) which suggested that additional language problems or more pervasive difficulties are related to more persisting difficulties, it was not obvious that the speech output constraint, rather than measures of language could be the more important factor in continued speech development. Nonetheless, it is acknowledged that, in the multiple regressions, by analysing the data using one heterogeneous group (which included children with different speech outcomes, level of speech severity and differing input and output skills) the unifying selection criterion of speech output could be over-emphasised as a predictor. Additionally, poorer expressive language scores could have been a partial consequence of reduced speech intelligibility. This shared variance between speech output and the expressive language composite might have made the comparison of these measures as independent predictors in the regressions questionable.

Examining more homogeneous groupings could clarify the potential masking effects of looking at a heterogeneous sample. For example, results of a multiple regression analysis of children with persisting speech difficulties (and excluding children whose problems would later resolve) would have more clearly shown the role of speech processing and language skills in a more tightly selected and defined speech disordered group. It was not possible to do this as the remaining sample would have been too small to carry out such analyses.

Factoring in heterogeneity was a deliberate choice in the design of this study. A principal aim of the longitudinal study was to track speech and language development across a sample selected from the broad clinical population of children considered to have primary speech disorder, in a similar way to the selection criterion of other longitudinal studies of children with speech/language disorder (e.g. Bishop & Edmundson, 1987a; Bird et al., 1995). A population sample was required for a number of reasons. Whilst much recent research has described the speech processing profiles of single cases, it was not known how frequent such profiles might be. The study therefore aimed to examine frequency of patterns of speech processing profile (e.g. word/nonword discrepancy) across the group and how such profiles changed over time. The fact that many children showed profiles similar to controls has important implications in how we characterise this population according to this paradigm. Additionally, the study aimed to replicate studies looking at co-occurrence of language difficulties in a population sample and then to extend the analysis by looking at patterns of co-occurrence over time, as well as the rate of development of these speech and language skills over the course of the study. It was predicted from other research that there would be a co-occurrence of input and language difficulties in a subset of this population. As well as confirming this, several novel findings were also uncovered as a result of using a heterogeneous and longitudinal sample. For example, it was found that: a) co-occurrence of difficulties remains fairly stable over time; b) a more pervasive profile of deficits in both input and language equates with a more persisting difficulty compared to a specific deficit; c) atypical speech processing profiles as measured by word/nonword repetition discrepancies are found in a minority of the population sample; d) measured by a composite of speech output tasks (pcc), speech disorders are hugely variable across the clinical population compared to the normal range of performance, and compared to input and language skills, and whilst improving rapidly between the ages of 4-6, remain more variable.

Given the methodological limitations of some of the tasks and measures of speech processing, there is a need for further analyses and research. The relationship between phonological error, speech severity and speech processing performance in the speech disordered group needs further investigation. Having identified in this study that speech input skills play such an important role in the development of speech output in the control group, and that speech output is the main constraint on speech development in the speech disordered group, it is crucial to search for more reliable and sensitive measures of speech input and to use more phonologically-based speech output tasks to replicate these findings.

11.3.6. Future directions

Several future directions are suggested as a result of this study:

1. **Phonology.** Phonological analyses were not conducted but it would be of interest to examine the relationship between types and extent of phonological processes and the levels of speech severity and the patterns of word/nonword repetition of the cohort.
2. **Motor programming.** If motor programming is a key deficit of some of these children, one would predict continued difficulty on nonword repetition tasks, so follow-up of this cohort is needed. It would also be important to link a psycholinguistic-style investigation of motor programming to more traditional measurements of these skills. Lack of a matched articulatory naming task made comparison with repetition tasks tentative in this study. It would be important to examine the question of motor programming and motor programs, with well designed output measures.
3. **Input processing.** Whilst a causal role for input processing was ruled out, deficits in input processing are an important clinical marker of a persisting speech problem. It is therefore important to develop reliable measures of speech input that retain validity and sensitivity over different ages.
4. **Linguistic processing.** Given the role of language identified in this study, experimental measures of linguistic processing should be developed in order to examine more specific relationships between speech and language processing.
5. **Connectionist modelling.** A connectionist paradigm was invoked to account for the interactive nature of the data. Historically, speech therapy has borrowed from different theoretical traditions in order to describe, explain and predict speech and language difficulties. Different approaches to phonology (structural, nonlinear etc.) have had a great impact on how speech disorders are described. Cognitive neuropsychology and psycholinguistics have had a more recent influence on processing explanations of speech disorder. Connectionist modelling, a major theoretical paradigm of the 1990s in the cognitive neurosciences, has several appealing theoretical principles (e.g. how we learn, interactive processing) that are applicable to a study of speech disorder (Baker, Croot, McLeod et al., 2001).

11.3.7. Summary and conclusions

The heterogeneity of the population of children with speech difficulties was seen as the main issue that theoretical accounts of speech disorder must address. This thesis has confirmed this heterogeneity. Children with primary significant speech difficulties presented with a range of speech/language difficulties and a range of outcomes was observed. Speech input difficulties were also observed in some of the group, including problems in the processing of speech variability.

Heterogeneity of outcome could have been explained by differing paths or patterns of development, i.e. by a different rate of development or by a pervasive compared to a specific profile of performance. However, it was argued that initial presenting speech difficulty accounted for differing outcomes rather than rate of development or pervasiveness of profile. For those with persisting speech difficulties, it was argued that the speech difficulty may have been as a result of motor programming problems, as revealed through nonword repetition. But as this was only found by examining the change that took place between T2 and T3, it was initial severity that was the best predictor of later speech development. There was also some evidence that children with speech difficulties were likely to have a delayed onset of speech/language development, so their difficulties in speech/language skill could be attributed to delay rather than different types of disorder. However, an alternative interpretation was that children were reported to have a delayed onset because their first words were likely to be less intelligible and identifiable than words spoken by normally developing children.

Whilst different speech/language profiles were found, defining different subgroups was problematic because criterion for membership was considered arbitrary and was reflected by some fluctuation over time. Further, children with different profiles differed in their levels of speech severity. Presenting difficulties were therefore argued to be mediated by the severity of the speech difficulty. However, the psycholinguistic principle of task comparison was productive when comparisons were specifically made over time. Exploring patterns of word/nonword performance over time found changing patterns, validating an examination of levels of speech processing ability and showing that persisting speech problems were associated with motor programming difficulties.

Whilst this finding is theoretically important, in terms of identifying clinical markers of good or poor speech outcome, severity of speech difficulty is an earlier identifier. Additional language difficulties and speech input problems are also reliable, early clinical markers, as these measures differentiated outcome subgroups from an early age, despite the theoretical argument made that these are not as successful as speech severity in accounting for and predicting outcome. It is acknowledged that the relationship between severity and associated, pervasive difficulties is difficult to tease apart, but the evidence from the longitudinal study found that development between the ages of four to six could be explained by the severity of the initial speech problem.

The interaction of speech output and speech input skills was explored within this study and informs an understanding of both normal and atypical speech development, by highlighting the associations of these skills, especially the role of input skills in later output skills. This developmental perspective, with a consideration of the whole speech processing system, as well as language skills, has enabled a better understanding of the course of speech difficulties between the ages of four and six. This perspective reveals that, without denying inherent variation, by an examination of development, it is possible to identify common factors that mediate change across the group.

References

Angold, A. Costello, E.J. & Erkanli, A. Comorbidity. (1999). *Journal of Child Psychology and Psychiatry*, 40, 1, 57-87.

Anastasi, A. (1976). *Psychological Testing.* New York: Macmillan.

Anthony, A., Bogle, D., Ingram, T.T.S. & McIsaac, M.W., (1971). *Edinburgh Articulation Test.* Edinburgh: Churchill Livingstone.

Arndt, W.B., Shelton, R.L., Johnson, A.F. & Furr, M.L. (1977). Identification and description of homogeneous subgroups within a sample of misarticulating children. *Journal of Speech and Hearing Research*, 20, 263-292.

Baker, E., Croot, K., McLeod, S. & Paul, R. (2001). Psycholinguistic models of speech development and their application to clinical practice. *Journal of Speech, Language and Hearing Research*, 44, 685-702.

Bates, E., Bretherton, I. & Snyder, L. (1988). *From first words to grammar: Individual differences and dissociable mechanisms.* Cambridge: C.U.P.

Beitchman, J.H., Wilson, B., Brownlie, E.B., Walters, H. & Lancee, W. (1996). Long-term consistency in speech/language profiles. 1. Developmental and academic outcomes. *Journal of the American Academy of Child and Adolescent Psychiatry*, 35, 6, 804-814.

Bergman, L.R., Eklund, G. & Magnusson, D. (1991). Studying individual development: problems and methods. In Magnusson, D., Bergman, L.R., Rudinger, G. & Torestad, B. (Eds), *Problems and methods in longitudinal research: Stability and change.* Cambridge: CUP.

Bernhardt, B.H. & Stemberger, J.P. (1998). *Handbook of phonological development: From the perspective of constraint-based nonlinear phonology.* London: Academic Press Ltd.

Best, C.T. (1994). The emergence of native-language phonological influences in infants: a perceptual assimilation model. In Goodman, J.C. & Nusbaum, H.C. (Eds), *The development of speech perception.* Cambridge, Mass: MIT Press.

Bird, J. & Bishop, D.V.M. (1992). Perception and awareness of phonemes in phonologically impaired children. *European Journal of Disorders of Communication* 27, 289-311.

Bird, J., Bishop D.V.M. & Freeman, N.H. (1995). Phonological awareness and literacy development in children with expressive phonological impairments. *Journal of Speech and Hearing Research* 38: 446-462.

Bishop D.V.M. (1983). *Test for the Reception of Grammar.* Manchester: Department of Psychology, University of Manchester.

Bishop D.V.M. (1997). *Uncommon understanding: Development and disorders of language comprehension in children.* Hove: Psychology Press Limited.

Bishop, D.V.M. & Adams, C. (1990). A prospective study of the relationship between specific language impairment, phonological disorders and reading retardation. *Journal of Child Psychology and Psychiatry,* 31: 1027-1050.

Bishop, D.V.M. & Edmundson, A. (1987a). Language impaired 4-year-olds: distinguishing transient from persistent impairment. *Journal of Speech and Hearing Disorders*, 52, 156-173.

Bishop, D.V.M. & Edmundson, A. (1987b). Specific language impairment as a maturational lag – evidence from longitudinal data on language and motor development. *Developmental Medicine and Child Neurology*, 29, 4, 442-459.

Bishop, D.V.M. Carlyon, R.P., Deeks, J.M. & Bishop, S.J. (1999). Auditory temporal processing impairment: neither necessary nor sufficient for causing language impairment in children. *Journal of Speech, Language and Hearing Research*, 42, 1295-1310.

Bishop, D.V.M., North, T. & Donlan, C. (1996). Nonword repetition as a behavioural marker for inherited language impairment: Evidence from a twin study. *Journal of Child Psychology and Psychiatry*, 37, 4, 391-403.

Black, M. (1997). Making new connections: are patterns emerging? In Chiat, S., Law, J. & Marshall, J. (Eds) *Language disorders in children and adults: psycholinguistic approaches to therapy*. London: Whurr Publishers.

Bradford, A. & Dodd, B. (1994). The motor planning abilities of phonologically disordered children. *European Journal of Communication Disorders*, 29, 4, 349-369.

Bradford, A. & Dodd, B. (1996). Do all speech-disordered children have motor deficits? *Clinical Linguistics and Phonetics*, 10, 2, 77-101.

Brett, L., Chiat, S. & Pilcher (1987). Stages and units in output processing: some evidence from voicing and fronting processes in children. *Language and Cognitive Processes*, 2, 165-177.

Bridgeman, E. & Snowling, M. (1988). The perception of phoneme sequence: a comparison of dyspraxic and normal children. *British Journal of Disorders of Communication* 23, 3: 245-252.

Broadbent, P. (2000). An investigation of the speech processing skills of children attending a mainstream primary school. *Unpublished Msc project, Department of Human Communication Science, University College London.*

Broen, P.A., Strange, W., Doyle, S.S. & Heller, J.H. (1983). Perception and production of approximant consonants by normal and articulation-delayed preschool children. *Journal of Speech and Hearing Research*, 26, 4, 601-608.

Bryan, A. (1995). Boxes and arrows for children. *Bulletin of the Royal College of Speech and Language Therapists*, 523, 14-16.

Bryan, A., & Howard, D. (1992). Frozen phonology thawed: The analysis and remediation of a developmental disorder of real word phonology. *European Journal of Disorders of Communication*, 27, 343-365.

Bryan, A., & North, C. (1994). Developmental cognitive neuropsychology: a comparison of two case studies. *Child Language Teaching and Therapy*, 10, 3, 313-327.

Bryant, P. (1990). Empirical evidence for causes in development. In Butterworth, G. & Bryant, P. (Eds), *Causes of development: Interdisciplinary perspectives*. Hemel Hempstead: Harvester Wheatsheaf.

Burnham, D.K. (1986). Developmental loss of speech perception: exposure to and experience with a first language. *Applied Psycholinguistics*, 7, 207-240.

Burnham, D.K., Earnshaw, L.J. & Clark, J.E. (1991). Development of categorical identification of native and nonnative bilabial stops – infants, children and adults. *Journal of Child Language*, 18, 2, 231-260.

Cantwell, D.P. & Baker, L. (1987). Prevalence and type of psychiatric disorder and developmental disorders in three speech and language groups. *Journal of Communication Disorders*, 20, 151-160.

Catts, H.W. (1993). The relationship between speech-language impairments and reading disabilities. *Journal of Speech and Hearing Research,* 36, 948-958.

Ceponiene, R. Service, E., Kurjenluoma, S., Cheour, M. & Naatanen, R. (1999). Children's performance on pseudoword repetition depends on auditory trace quality: Evidence from event-related potentials. *Developmental Psychology*, 35, 709-720.

Chambers, J.K. (1992). Dialect acquisition. *Language*, 68.4, 673-705.

Chambers, J.K. & Trudgill, P. (1980). *Dialectology*. Cambridge: CUP.

Cheour, M., Ceponiene, R., Lehtokoski, A., Luuk, A., Allik, J., Alho, K & Naatanen, R. (1998). Development of language-specific phoneme representations in the infant brain. *Nature Neuroscience*, 1, 5, 351-353.

Chiat, S. (1983). Why *Mikey's* right and *my key's* wrong: the significance of stress and word boundaries in a child's output system. *Cognition,* 14, 275-300.

Chiat, S. (1997). Making new connections: in whose interests? In Chiat, S., Law, J. & Marshall, J. (Eds) *Language disorders in children and adults: psycholinguistic approaches to therapy*. London: Whurr Publishers.

Chiat, S. (2000). *Understanding children with language problems*. Cambridge: CUP.

Chiat, S. (2001). Mapping theories of developmental language impairment: premises, predictions and evidence. *Language and Cognitive Processes*, 16, 113-142.

Chiat, S. & Hunt, J. (1993). Connections between phonology and semantics: an exploration of lexical processing in a language-impaired child. *Child Language Teaching and Therapy*, 9, 3, 200-213.

Cohen, W. & Waters, D. (1999). Measuring speech motor skills in normally developing and phonologically disordered pre-school children. *Proceedings of the XIVth International Congress of Phonetic Sciences*, 1, 789-792.

Collins, T. (1998). A developmental study of the effects of accent variation on single word comprehension in eight and nine year old children. *Unpublished Bsc speech sciences project, Department of Human Communication Science, University College London.*

Constable, A., Stackhouse, J. & Wells, B. (1997). Developmental word finding difficulties and phonological processing: the case of the missing handcuffs. *Applied Psycholinguistics*, 18, 4, 507-536.

Conti-Ramsden, G. & Botting, N. (1999). Classification of children with specific language impairment: longitudinal considerations. *Journal of Speech, Language and Hearing Research*, 42, 1195-1204.

Conti-Ramsden, G., Botting, N., Simkin, Z. & Knox, E. (2001). Follow-up of children attending infant language units: outcomes at 11 years of age. *International Journal of Language and Communication Disorders*, 36, 2, 207-219.

Conti-Ramsden, G., Crutchley, A. & Botting, N. (1997). The extent to which psychometric tests differentiate subgroups of children with SLI. *Journal of Speech, Language and Hearing Research*, 40, 765-777.

Crary, M.A. (1993). *Developmental motor speech disorders*. London: Whurr publishers.

Dodd, B. (1975). Children's understanding of their own phonological forms. *Quarterly Journal of Experimental Psychology*, 27, 165-172.

Dodd, B. (1995). *Differential Diagnosis and Treatment of Children with Speech Disorder.* London: Whurr Publishers.

Dodd, B. Leahy, J. & Hambly, G. (1989). Phonological disorders in children: Underlying cognitive deficits. *British Journal of Developmental Psychology*, 7, 55-71.

Dollaghan, C.A., Biber, M.E. & Campbell, T.F. (1995). Lexical influences on nonword repetition. *Applied Psycholinguistics*, 16, 2, 211-222.

Dunn, L.M., Dunn, L.M., Whetton, C.& Pintilie, D.(1982). *The British Picture Vocabulary Scales.* Windsor, Berks: NFER-Nelson.

Edwards J., Fourakis M., Beckman M.E. & Fox R.A. (1999). Characterizing knowledge deficits in phonological disorders. *Journal of Speech, Language and Hearing Research*, 42, 1,169-186.

Edwards, J. & Lahey, M. (1998). Nonword repetitions of children with specific language impairment: Exploration of some explanations for their inaccuracies. *Applied Psycholinguistics*, 19, 2, 279-309.

Eimas, P.D., Siqueland, E.R., Jusczyk, P.W. & Vigorito, J. (1971). Speech perception in early infancy. *Science*, 171, 304-306.

Elbro, C., Borstrom, & Peterson, D.K. (1998). Predicting dyslexia from kindergarten: The importance of distinctness of phonological representations of lexical items. *Reading Research Quarterly*, 33, 1, 36-60.

Elliott, L.L., Hammer, M.A. & Evan, K.E. (1987). Perception of gated, highly familiar spoken monosyllabic nouns by children, teenagers, and older adults. *Perception and Psychophysics*, 42, 2, 150-157.

Elliott, L.L., Hammer, M.A., Scholl, M.E. (1989). Fine-grained auditory discrimination in normal children and children with language learning problems. *Journal of Speech and Hearing Research*, 32, 1, 112-119.

Elliott, C.D., Murray, D.J. & Pearson, L.S. (1983). *British Ability Scales.* Windsor: NFER-Nelson.

Ellis, A.W. & Young, A.W. (1988). *Human cognitive neuropsychology.* Hove: Erlbaum.

Elman, J.L., Bates, E.A., Johnson, M.H., Karmiloff-Smith, A, Parisi, D. & Plunkett, K. (1998). *Rethinking innateness: A connectionist perspective on development*. London: MIT press.

Enderby, P. & Philipp, R. (1986). Speech and language handicap – towards knowing the size of the problem. *British Journal of Disorders of Communication*, 21, 2, 151-165.

Evans, J.L. (2001). An emergent account of language impairments in children with SLI: Implications for assessment and intervention. *Journal of Communication Disorders*, 34, 39-54.

Felsenfeld, S., Broen, P.A. & McGue. (1992). A 28-year follow-up of adults with a history of moderate phonological disorder: linguistic and personality records. *Journal of Speech and Hearing Research*, 35, 1114-1125.

Flege, J.E. (1984). The detection of foreign accent by American listeners. *Journal of the Acoustical Society of America*, 76, 692-707.

Forrest, K, Chin, S.B., Pisoni, D.B. & Barlow, N.N. (1994). Talker normalization in normally articulating and phonologically delayed children: Methodological considerations. *Research on spoken language processing, Progress Report No. 19 (1993-1994), Indiana University*, 229-250.

Fowler, A.E. (1991). How early phonological development might set the stage for phoneme awareness. In Brady, S.A., Shankweiler, D.P. (Eds) *Phonological processes in literacy: A tribute to Isabelle Liberman*. Hillsdale, NJ: Erlbaum.

Frith, U. & Happé, F. (1998). Why specific developmental disorders are not specific : on-line and developmental effects in autism and dyslexia. *Developmental Science*, 1, 267-272.

Ganong, W.F. (1980). Phonetic categorisation in auditory word perception. *Journal of Experimental Psychology: Human Perception and Performance*, 6, 1, 110-125.

Gathercole, S.E. (1995). Is nonword repetition a test of phonological memory or long-term knowledge – it all depends on the nonwords. *Memory and Cognition*, 23, 83-94.

Gathercole, S.E. & Baddeley, A.D. (1990). Phonological memory deficits in language disordered children – is there a casual connection. *Journal of Memory and Language*, 29, 3, 336-360.

Gathercole, S.E., Willis, C.S., Emslie, H. & Baddeley, A.D. (1991). The influences of number of syllables and wordlikeness on children's repetition of nonwords. *Applied Psycholinguistics*, 12, 3, 349-367.

Gathercole, S.E., Willis, C.S., Baddeley, A.D. & Emslie, H. (1994). The children's test of nonword repetition: A test of phonological working memory. *Memory*, 2, 2, 103-127.

Glogowska M., Roulstone S., Enderby P. & Peters, T.J. (2000). Randomised controlled trial of community based speech and language therapy in preschool children. *British Medical Journal*, 321, 923-926.

Goldinger, S.D. (1996). Auditory lexical decision. *Language and Cognitive Processes*, 11, 6, 559-567.

Goldman, R., Fristoe, M. & Woodcock, R. (1975). *Goldman-Fristoe-Woodcock auditory skills test battery.* Minnesota : American Guidance Service.

Goodman, R. (1997). The Strengths and Difficulties Questionnaire: A research note. *Journal of Child Psychology and Psychiatry and Allied Disciplines*. 38, 5, 581-586.

Groenen, P., Maassen, B., Crul, T. & Thoonen, G. (1996). The specific relation between perception and production errors for place of articulation developmental apraxia of speech. *Journal of Speech and Hearing Research*, 39, 3, 468-482.

Grunwell, P. (1982). *Clinical Phonology.* London: Croom Helm.

Grunwell, P. (1987). *Clinical Phonology.* 2nd Edition. London: Chapman & Hall.

Hair, J.F., Anderson, R.E., Tatham, R.L. & Black, W.C. (1998). *Multivariate Data Analysis*. 5th Edition. New Jersey: Prentice-Hall International, Inc.

Hall, P.K. & Tomblin, B. (1978). A follow-up study of children with articulation and language disorders. *Journal of Speech and Hearing Disorders*, 43, 227-241.

Hargreaves, R. (1971). *Mr. Tickle.* Manchester: World International Publishing Limited.

Hargreaves, R. (1976). *Mr. Strong.* Manchester: World International Publishing Limited.

Haynes, C. & Naidoo, S. (1991). *Children with specific speech and language impairment* London: MacKeith Press.

Hazan, V. & Barrett, S. (2000). The development of phonemic categorisation in children aged 6 to 12. *Journal of Phonetics*, 28, 4, 377-396.

Hazan, V., Wilson, G., Howells, D., Miller, D., Abberton, E. & Fourcin, A. (1995). Speech pattern audiometry for clinical use. *European Journal of Disorders of Communication*, 30, 2, 116-123.

Henry, C.E. (1990). The development of oral diadochokinesia and non-linguistic rhythmic skills in normal and speech-disordered young children. *Clinical Linguistics and Phonetics*, 4, 2, 121-137.

Hewlett, N. (1990). Processes of development and production. In P. Grunwell (Ed), *Developmental speech disorders: clinical issues and practical implications*. Edinburgh: Churchill Livingstone.

Hewlett, N., Gibbon, F. & Cohen-McKenzie, W. (1998). When is a velar an alveolar? Evidence supporting a revised psycholinguistic model of speech production in children. *International Journal of Language and Communication Disorders*, 2, 161-176.

Himmelwright Gross, G., St. Louis, K., Ruscello, D.M. & Hall, F.M. (1985). Language abilities of articulatory-disordered school children with multiple or residual errors. *Language, Speech and Hearing Services in Schools*, 171-186.

Hintzman, D.L. (1986). "Schema Abstraction" in a multiple-trace memory model. *Psychological Review,* 93, 411-28.

Hodson, B.W. (1994). Helping individuals become intelligible, literate, and articulate: The role of phonology. *Topics in Language Disorders*, 14, 2, 1-16.

Hoffman, P. (1992). Synergistic development of phonetic skill. *Language, Speech and Hearing Services in Schools*, 23, 225-232.

Howell, D.C. (1982). *Statistical methods for psychology.* Boston, Mass.: PWS Publishers.

Hulme, C. & Snowling, M. (1992). Deficits in output phonology: an explanation of reading failure? *Cognitive Neuropsychology*, 9, 1, 47-72.

Ingram, D. (1976). *Phonological disability in children.* London: Edward Arnold.

Johnson, C.J., Beitchman, J.H., Young, A., Escobar, M. Atkinson, L. Wilson, B. Brownlie, E.B., Douglas, L., Taback, N., Lam, I. & Wang, M. (1999). Fourteen-year follow-up of children with and without speech language impairments: speech language stability and outcomes. *Journal of Speech, Language and Hearing Research*, 42, 744-460.

Jusczyk, P. (1992). Developing phonological categories from the speech signal. In Ferguson, C.A., Menn, L. & Stoel-Gammon, C. (Eds), *Phonological development: models, research, implications*. Parkton, MD: York Press.

Karmiloff-Smith, A. (1998). Is atypical development necessarily a window on the normal mind / brain? The case of Williams syndrome. *Developmental Science*, 1, 2, 273-277.

Kent, R.D. (1996). Developments in the theoretical understanding of speech and its disorders. In Ball, M.J. & Duckworth, M. (Eds), *Advance in Clinical Phonetics*. Amsterdam: John Benjamins Publishing Company.

Kent, R.D. & Miolo, G. (1995). Phonetic abilities in the first year of life. In Fletcher, P. & MacWhinney, B. (Eds), *The Handbook of Child Language*. Oxford: Blackwell Publishers.

Kerswill P. & Williams, A. (2000). Creating a New Town koine: Children and language change in Milton Keynes. *Language in Society*, 29,1, 65-115.

Kirkpatrick, E. & Ward, J. (1984). Prevalence of articulation errors in New South Wales primary school pupils. *Australian Journal of Human Communication Disorders*, 12, 55-62.

Kline, P. (2000). *Handbook of Psychological Testing*. 2nd Edition. London, Routledge.

Labov, W. (1989). The Limitations of context: Evidence from misunderstandings in Chicago. *Chicago Linguistic Society, 25,* 171-200.

Lambert, J. & Waters, D. (1995). Childhood phonological disorders. In M.M. Leahy (Ed), *Disorders of communication: The science of intervention*. London: Whurr publishers.

Larrivee, L.S. & Catts, H.W. (1999). Early reading achievement in children with expressive phonological disorders. *American Journal of Speech-Language Pathology*, 8, 118-128.

Law, J., Boyle, F., Harris, F., Harkness, A. & Nye, C. (1998). Screening for speech and language delay: a systematic review of the literature. *Health Technol Assessment*, 2, 9.

Law, J., Boyle, F., Harris, F., Harkness, A. & Nye, C. (2000). Prevalence and natural history of primary speech and language delay: findings from a systematic review of the literature. *International Journal of Language and Communication Disorders*, 35, 2, 165-188.

Law, J. & Conti-Ramsden, G. (2000). Treating children with speech and language impairments - Six hours of therapy is not enough. *British Medical Journal*, 321, 7266, 908-909.

Leahy, J. & Dodd, B. (1987). The development of disordered phonology: a case study. *Language and Cognitive Processes*, 2, 115-132.

Leitao, S. Hogben, J. & Fletcher, J. (1997). Phonological processing skills in speech and language impaired children. *European Journal of Disorders of Communication*, 32, 2, 91-113.

Lewis, B.A. (1992). Pedigree analysis of children with phonology disorders. *Journal of Learning Disabilities*, 25, 9, 586-597.

Lewis, B.A., Ekelman, B.L. & Aram, D.M. (1989). A familial study of severe phonological disorders. *Journal of Speech and Hearing Research*, 32, 4, 713-724.

Lewis, B.A. & Freebairn, L. (1992). Residual effects of preschool phonology disorders in grade school adolescence and adulthood. *Journal of Speech and Hearing Research,* 35, 819-831.

Lewis, B.A., Freebairn, L. & Taylor, H.G. (2000a). Follow-up of children with early expressive phonology disorders. *Journal of Learning Disabilities*, 33, 433-444.

Lewis, B.A., Freebairn, L. & Taylor, H.G. (2000b). Academic outcomes in children with histories of speech sound disorders. *Journal of Communication Disorders*, 33, 11-30.

Locke, J.L. (1980). The inference of speech perception in the phonologically disordered child. Part II: some clinically novel procedures, their use, some findings. *Journal of Speech and Hearing Disorders* 45, 445-468.

Locke, J.L. (1993). *The child's path to spoken language.* Cambridge, Mass: Harvard University Press.

Long, M.H. (1990). Maturational constraints on language development. *Studies in second language acquisition*, 12, 251-285.

McCabe, P., Rosenthal, J.B. & McLeod, S. (1998). Features of developmental dyspraxia in the general speech-impaired population? *Clinical Linguistics and Phonetics*, 12, 2, 105-126.

Macmillan, N.A. & Creelman, C.D. (1991). *Detection Theory: A User's Guide.* Cambridge: CUP.

Marquardt, T.P. & Saxman, H.J. (1972). Language comprehension and auditory discrimination in articulation deficient kindergarten children. *Journal of Speech and Hearing Research*, 15, 382-389.

Mirak, J. & Rescorla, L. (1998). Phonetic skills and vocabulary size in late talkers: concurrent and predictive relationships. *Applied Psycholinguistics.* 19,1, 1-17.

Mitrushina, M., Boone, K. & D'Elia, L. (1999). *Handbook of normative data for neuropsychological assessment.* Oxford: OUP.

Mody, M. Schwartz, R., Gravel, J., Ruben, R. (1999). Speech perception and verbal memory in children with and without histories of otitis media. *Journal of Speech, Language and Hearing Research,* 42, 5, 1069-1079.

MorganBarry, R. (1988). *The Auditory Discrimination and Attention Test.* Windsor: NFER-Nelson.

Munro, M.J., Derwing, T.M. & Flege, J.E. (1999). Canadians in Alabama: A perceptual study of dialect acquisition in adults. *Journal of Phonetics*, 27, 385-403.

Nash, P., Stengelhofen, J., Toombs, L., Brown, J. & Kellow, B. (2001). An alternative management of older children with persisting communication problems. *Proceedings of RCSLT Conference, Birmingham, April, International Journal of Language & Communication Disorders of Communication,* 36, Supplement, 179-184.

Nathan, L. (1994). A developmental study of the effects of accent variation on single word comprehension. *Msc thesis in Speech and Language Pathology and Therapy, Institute of Neurology, London University.*

Nathan, L. & Wells, B. (in press). Can children with speech difficulties process an unfamiliar accent? To appear in *Applied Psycholinguistics.*

Nathan, L. & Wells, B. (in progress). *Processing speech variability.* Economic and Social Research Council (ESRC Award No: R000223043)

Nathan, L., Wells, B. & Donlan, C. (1998). Children's comprehension of unfamiliar regional accents: A preliminary investigation. *Journal of Child Language*, 25, 343-365.

Nimmo, E. (1998). Speech processing and literacy skills in children whose speech difficulties appear to have resolved. *Unpublished Msc speech sciences project, Department of Human Communication Science, University College London.*

Nittouer, S. (1992). Age-related differences in perceptual effects of formant transitions within syllables and across syllable boundaries. *Journal of Phonetics*, 20, 3, 351-382.

Nittrouer, S. & Crowther, C.S. (1998). Examining the role of auditory sensitivity in the developmental weighting shift. *Journal of Speech, Language and Hearing Research*, 41, 4, 809-818.

Nittrouer, S. & Studdert-Kennedy, M. (1987). The role of coarticulatory effects in the perception of fricatives by children and adults. *Journal of Speech and Hearing Research*, 30, 3, 319-329.

Nittrouer, S., Studdert-Kennedy, M. & McGowan, R.S. (1989). The emergence of phonetic segments – evidence from the spectral structure of fricative-vowel syllables spoken by children and adults. *Journal of Speech and Hearing Research*, 32, 1, 120-132.

Nygaard, L.C. & Pisoni, D. B. (1998). Talker-specific learning in speech perception. *Perception and Psychophysics*, 60, 3, 355-376.

Ozanne, A. (1995). The search for developmental verbal dyspraxia. In Dodd, B. (Ed), *Differential diagnosis and treatment of children with speech disorder*. London: Whurr publishers.

Pate, E. (1998). A developmental study of the effects of accent variation on single word comprehension in five and six year old children. *Unpublished Bsc speech sciences project, Department of Human Communication Science, University College London.*

Paul, R. & Jennings, P. (1992). Phonological behavior in toddlers with slow expressive language development. *Journal of Speech, Hearing and Language Research*. 35, 1, 99-107.

Paul, R., Murray, C., Clancy, K. & Andrews, D. (1997). Reading and metaphonological outcomes in late talkers. *Journal of Speech, Hearing and Language Research*, 40, 5, 1037-1047.

Paul, R. & Shriberg, L. (1982). Associations between phonology and syntax in speech-delayed children. *Journal of Speech and Hearing Research*, 25, 536-547.

Payne, A. (1980). Factors controlling the acquisition of the Philadelphia dialect by out-of-state children. In Labov, W. (Ed), *Locating language in time and space*. New York: Academic Press 1.

Powell, T.W., Elbert, M. & Dinnsen, D.A. (1999). A follow-up study of the linguistic and intellectual abilities of children who were phonologically disordered. In Maassen, B. & Groenen, P. (Eds), *Pathologies of speech and language: Advances in clinical phonetics and linguistics*. London: Whurr.

Primary School Performance Tables (1999). Department for Education and Employment.

Raaymakers, E.M.J.A. & Crul, T.A.M. (1988). Perception and production of the final /s-ts/ contrast in Dutch by misarticulating children. *Journal of Speech and Hearing Disorders*, 53, 262-270.

Rapin, I. & Allen, D.A. (1987). Developmental dysphasia and autism in preschool children: Characteristics and subtypes. In Martin, J., Fletcher, P., Grunwell, P. & Hall, D. (Eds), *Proceedings of the first international symposium on specific speech and language disorders in children*. London: AFASIC.

Rees, R. (2001). Principles of psycholinguistic intervention. In Stackhouse, J. & Wells, B. (Eds), *Children's speech and literacy difficulties: Book Two: Identification and intervention*. London: Whurr Publishers.

Renfrew, C.E. (1988). *Renfrew Action Picture Test* (3rd Edition). Oxford: Language Test Publisher.

Renfrew, C.E. (1995). *The Renfrew Bus Story* (UK 3rd Edition). Oxford: C.E. Renfrew.

Rescorla, L., & Schwartz, E. (1990). Outcome of toddlers with specific expressive language delay. *Applied Psycholinguistics*, 11, 4, 393-407.

Ripley, K., Daines, B. & Barrett, J. (1997). *Dyspraxia: A guide for teachers and parents.* London: David Fulton Publishers.

Rvachew, S. & Jamieson, D.G. (1989). Perception of voiceless fricatives by children with a functional articulation disorder. *Journal of Speech and Hearing Disorders*, 54, 2, 193-208.

Ryalls, B.O. & Pisoni, D.B. (1997). The effect of talker variability on word recognition in preschool children. *Developmental Psychology*, 33, 3, 441-52.

Sahlen, B., Reuterskiold-Wagner, C., Nettelbladt, U. & Radeborg, K. (1999). Non-word repetition in children with language impairment – pitfalls and possibilities. *International Journal of Language and Communication Disorders*, 34, 337-352.

Schmid, M. & Yeni-Komshian, G. (1999). The effects of speaker accent and target predictability on perception of mispronounciations. *Journal of Speech, Language and Hearing Research*, 42, 56-64.

Scovel, T. (1981). The recognition of foreign accents. In Savard, J-G. & LaForge, L. (Eds) *Proceedings of the 5th Congress of the International Association of Applied Linguistics*. Quebec: U of Laval Press.

Shallice, T. (1988). *From neuropsychology to mental structure.* Cambridge: CUP.

Shaywitz, B.A., Holford, T.R., Holahan, J.M., Fletcher, J.M., Stuebing, K., Francis, D.J. & Shaywitz, S.E. (1995). A Matthew effect for IQ but not for reading – results from a longitudinal study. *Reading Research Quarterly*, 30, 4, 894-906.

Shriberg, L.D. (1997). Developmental phonological disorders: one or many? In Hodson, B. & Edwards, M.L. (Eds), *Perspectives in Applied Phonology.* Maryland: Aspen Publications.

Shriberg, L.D., Aram, D.M. & Kwiatowski, J. (1997). Developmental apraxia of speech 1. Descriptive and theoretical perspectives. *Journal of Speech, Language and Hearing Research*, 40, 2, 273-285.

Shriberg, L.D., Austin, D., Lewis, B.A., McSweeny, J.L. & Wilson, D.L. (1997). The Speech Disorders Classification System (SDCS): Extensions and lifespan reference data. *Journal of Speech, Language and Hearing Research*, 40, 4, 723-740.

Shriberg, L.D., Austin, D., Lewis, B.A., McSweeny, J.L. & Wilson, D.L. (1997). The percentage of consonants correct (PCC) metric: Extensions and reliability data. *Journal of Speech, Language and Hearing Research*, 40, 708-722.

Shriberg, L., Flipsen, P., Thielke, H. Kwiatkowski, J., Kertoy, M. Katcher, M., Nellis, R. & Block, M. (2000). Risk for speech disorder associated with early recurrent otitis media with effusion: Two retrospective studies. *Journal of Speech, Language and Hearing Research*, 43, 79-99.

Shriberg, L., Friel-Patti, S., Flipsen, P. & Brown, R. (2000). Otitis media, fluctuant hearing loss, and speech-language outcomes: a preliminary structural equation model. *Journal of Speech, Language and Hearing Research*, 43, 100-120.

Shriberg, L. & Kwiatkowski, J. (1982). Phonological disorders III: A procedure for assessing severity of involvement. *Journal of Speech and Hearing Disorders*, 47, 256-270.

Shriberg, L. & Kwiatkowski, J. (1988). A follow-up study of children with phonologic disorders of unknown origin. *Journal of Speech and Hearing Disorders*, 53, 2, 144-155.

Shriberg, L.D., & Kwiatkowski, J. (1994). Developmental Phonological Disorders 1: A clinical profile. *Journal of Speech and Hearing Research*, 37, 1100-1126.

Shriberg, L.D, Kwiatkowski, J., & Gruber, F.A. (1994). Developmental Phonological Disorders II: Short-term speech-sound normalization. *Journal of Speech and Hearing Research*, 37, 1127-1150.

Shriberg L.D., Tomblin J.B. & McSweeny J.L. (1999). Prevalence of speech delay in 6-year-old children and comorbidity with language impairment. *Journal of Speech, Language and Hearing Research*, 42, 6, 1461-1481.

Smit, A.B. & Bernthal, J.E. (1983). Performance of articulation-disordered children on language and perception measures. *Journal of Speech and Hearing Research*, 26, 124-136.

Smith, N. (1973). *The Acquisition of Phonology: A case study*. Cambridge: C.U.P.

Snowling, M. J. (2000). *Dyslexia*. 2nd Edition. Oxford: Blackwell Publishers.

Snowling, M., Bishop, D.V.M. & Stothard, S.E. (2000). Is preschool language impairment a risk factor for dyslexia in adolescence? *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 41, 5, 587-600.

Snowling, M., Chiat, S. & Hulme, C. (1991). Words, nonwords, and phonological processes – some comments on Gathercole, Willis, Emslie and Baddeley. *Applied Psycholinguistics*, 13, 3, 369-373.

Snowling, M., Van Wagtendonk, B. & Stafford, C. (1988). Object naming deficits in developmental dyslexia. *Journal of Research in Reading,* 11, 67-85.

St. Louis, K.O., Ruscello, D.M. & Lundeen, C. (1992). Coexistence of communication disorders in schoolchildren. *ASHA Monographs* No. 27. Maryland: American Speech-Language-Hearing Association.

Stackhouse, J. (1992). Developmental Verbal Dyspraxia. 1. A review and critique. *European Journal of Disorders of Communication*, 27, 1, 19-34.

Stackhouse, J. (1993). Phonological disorder and lexical development: Two case studies. *Child Language Teaching and Therapy,* 9, 3, 230-241.

Stackhouse, J. (2000). Barriers to literacy development in children with speech and language difficulties. In Bishop, D.V.M. & Leonard, L. (Eds) *Speech and language impairments in children: Causes, characteristics, intervention and outcome.* Hove: Psychology Press.

Stackhouse, J., Nathan, L., Goulandris, N. & Snowling, M. (unpublished). *The relationship between speech disorders and literacy problems: Identification of the at risk child. Report on a 4 year longitudinal study.* Department of Human Communication Science, University College London.

Stackhouse, J. & Wells, B. (1993). Psycholinguistic assessment of developmental speech disorders. *European Journal of Disorders of Communication*, 28, 331-348.

Stackhouse, J. & Wells, B. (1996). Developmental Supermodels. *Bulletin of the Royal College of Speech and Language Therapists*, 527, 9-10.

Stackhouse, J. & Wells, B. (1997). *Children's Speech and Literacy Difficulties: A Psycholinguistic Framework.* London: Whurr Publishers.

Stackhouse, J. & Wells, B. (2001). *Children's speech and literacy difficulties: Book Two: Identification and intervention.* London: Whurr Publishers.

Standard occupational classification Employment Department Group, Office of Population Censuses and Surveys. (1995) 2nd Edition, Vol 2 Coding Index. London HMSO: (Great Britain Office of Population Censuses and Surveys).

Stark, R.E. & Tallal, P. (1981). Selection of children with specific language deficits. *Journal of Speech and Hearing Disorders*, 46, 114-122.

Stemberger, J.P. (1992). A connectionist view of child phonology: phonological processing without phonological processes. In Ferguson, C.A., Menn, L. & Stoel-Gammon, C. (Eds), *Phonological development: Models, Research, Implications.* Maryland, York Press.

Stoel-Gammon, C. (1991). Theories of phonological development and their implications for phonological disorders. In M.S. Yavas (Ed). *Phonological disorders in children: Theory, research and practice.* London: Routledge.

Stothard, S.E., Snowling, M., Bishop, D.V.M., Chipchase, B.B. & Kaplan, C.A. (1998). Language-impaired preschoolers: A follow-up into adolescence. *Journal of Speech, Language and Hearing Research,* 41, 407-418.

Stuart-Smith, J. (1999). Glasgow: Accent and voice quality. In Foulkes, P. & Docherty, G. (Eds), *Urban Voices: Accent studies in the British Isles.* Sevenoaks: Edward Arnold.

Studdert-Kennedy, M. (1987). The phoneme as a perceptuomotor structure. In Allport, A., MacKay, D., Prinz, W. & Scheerer, E. (Eds), *Language perception and production: Relationships between listening, speaking, reading and writing.* Orlando, FL: Academic Press.

Sussman, J.E. (1993). Perception of formant transition cues to place of articulation in children with language impairments. *Journal of Speech and Hearing Research*, 36, 6, 1286-1299.

Tallal, P. (2000). Experimental studies of language learning impairments: From research to remediation. In Bishop, D.V.M. & Leonard, L. (Eds), *Speech and language impairments in children: Causes, characteristics, intervention and outcome.* Hove: Psychology Press.

Temple, C. (1997). *Developmental Cognitive Neuropsychology.* Hove: Psychology Press.

Thurston, A. (1999). An investigation into the link between speech processing abilities, language skills and literacy development: a follow-up study of children whose speech difficulties appeared to have resolved. *Unpublished Msc speech sciences project, Department of Human Communication Science, University College London.*

Tomblin, J.B. (1990). The effect of birth order on the occurrence of developmental language impairment. *British Journal of Disorders of Communication.* 25, 1, 77-84.

Vance, M. (1996). Assessing speech processing skills in children: a task analysis. In Snowling, M. & Stackhouse, J. (Eds), *Dyslexia, Speech and Language: A practitioner's handbook.* London: Whurr Publishers.

Vance, M. (2001). Speech processing and short term memory in children with normal and atypical language development. *Unpublished PHd thesis, Department of Human Communication Science, University College London.*

Vance, M., Stackhouse, J. & Wells, B. (1995). The relationship between naming and word repetition skills in children age 3-7 years. Department of Human Communication Science, University College London: *Work in Progress*, 4, 171-185.

Vihman, M. (1996). *Phonological development: the origins of language in the child.* Oxford: Blackwell.

Walley, A.C. (1993). The role of vocabulary development in children's spoken word recognition and segmentation ability. *Developmental Review*, 13, 286-350.

Walley, A.C. & Flege, J.E. (1999). Effect of lexical status on children's and adults' perception of native and non-native vowels. *Journal of Phonetics*, 27, 3, 307-332.

Waters, D. (2001). Using input processing strengths to overcome speech output difficulties. In Stackhouse, J. & Wells, B. (Eds), *Children's speech and literacy difficulties: Book Two: Identification and intervention.* London: Whurr Publishers.

Watson, J. & Hewlett, N. (1998). Perceptual strategies in phonological disorder: assessment, remediation and evaluation. *International Journal of Language and Communication Disorders*, Proceedings of the College's 1998 Conference, Liverpool, Supplement, 33, 475-480.

Webster P.E. & Plante, A.S. & Couvillion, L.M. (1997). Phonological impairment and prereading: Update on a longitudinal study. *Journal of Learning Disabilities.* 30, 4, 365-375.

Wechsler, D. (1990). *Wechsler Preschool and Primary Scale of Intelligence - Revised (WPSSI-R UK).* Third UK Edition. London: The Psychological Corporation.

Wechsler, D. (1992). *Wechsler Intelligence Scale for children (WISC-III^{UK}).* Third Edition. Harcourt Brace Yanovich: New York.

Weismer, G. (1984). Acoustic analysis strategies for the refinement of phonological analysis. In Elbert, M., Dinnsen, D.A. & Weismer, G. (Eds) *Phonological theory and the misarticulating child.* Rockville, Md.: American Speech-Language-Hearing Association.

Wells, B. (1995). Phonological considerations in repetition tests. *Cognitive Neuropsychology*, 12, 8, 847-855.

Wells, J.C. (1982). *Accents of English Volume 2: the British Isles.* Cambridge: C.U.P.

Wepman, J.M. (1973). *Auditory discrimination test.* Palm Springs: Language Research Associates.

Werker, J.F. & Tees, R.C. (1984). Cross-language speech perception: evidence for perceptual reorganization during the first year of life. *Infant Behavior and Development*, 7, 49-63.

Williams, N. & Chiat, S. (1993). Processing deficits in children with phonological disorder and delay: a comparison of responses to a series of output tasks. *Clinical Linguistics and Phonetics*, 7, 2, 145-160.

Winitz, H. (1984). Auditory considerations in articulation training. In Winitz, H. (Ed), *Treating articulation disorders: for clinicians by clinicians.* Baltimore: University Park. Press.

World Health Organization. (1993). *The ICD-10 classification for mental and behavioural disorders: Diagnostic criteria for research.* Geneva, Switzerland: WHO.

Appendices

1. Note of scoring speech output tasks
2. Word and nonword repetition (original version): List of stimuli
3. Low Frequency word and nonword repetition (extension): List of stimuli
4. Articulatory naming task: List of stimuli
5. Auditory discrimination: same/different task: List of stimuli
6. Auditory discrimination: ABX task: List of stimuli
7. Auditory discrimination: picture task (original version): List of stimuli
8. Auditory discrimination: picture task (Extension task): List of stimuli
9. Accent auditory lexical decision task: List of stimuli
10. Developmental questionnaire
11. Parental questionnaire (mother)
12. Parental questionnaire (father)
13. Therapy record form (up till T1)
14. Therapy record form (T1-T2; T2-T3)

Note on scoring speech output tasks

Scoring of all speech output tasks was based on a broad phonetic transcription that was undertaken live and then checked against the tape-recording at a later stage. Reliability measures are described in the text.

All consonantal errors were treated equally in the scoring system of pcc on all speech output tasks. Distortions, omissions and substitutions were all scored as errors. Vowel performance was not scored.

Word and nonword repetition (original version): List of stimuli

1-syllable

	word	*nonword*
1	snake	/snaɪk/
2	van	/vɪn/
3	plate	/pləʊt/
4	fish	/fɛʃ/
5	train	/tɹɔɪn/
6	brush	/bɹɪʃ/
7	sponge	/spændʒ/
8	glove	/glɛv/

2-syllable

9	guitar	/gɛˈtɔ/
10	sausage	/ˈsɛsədʒ/
11	slipper	/ˈslɔpə/
12	yellow	/ˈjælɔɪ/
13	tractor	/ˈtɹɛktɪ/
14	jelly	/ˈdʒʌlə/
15	spider	/ˈspɛɪdɪ/
16	flower	/ˈfluwɪ/

3/4-syllable

17	elephant	/ˈælɪfɒnt/
18	umbrella	/æmˈbɹælɪ/
19	butterfly	/ˈbætəfləʊ/
20	parachute	/ˈpɛɹəʃit/
21	aeroplane	/ˈɒɹəpləʊn/
22	caterpillar	/ˈkɪtəpælə/
23	pyjamas	/pɪˈdʒɔmɪz/
24	spaghetti	/spʌˈgɪtə/

Word list devised by Vance, Stackhouse & Wells (1995), UCL

Low Frequency word and nonword repetition (extension): List of stimuli

	word	*nonword*
	1-syllable	
1	squeak	/skwuk/
2	crutch	/kɹɛtʃ/
3	wasp	/wɛsp/
4	bran	/bɹɒn/
	2-syllable	
5	cartridge	/kitɹʊdʒ/
6	cricket	/kɹɒkɒt/
7	drummer	/dɹɒmɪ/
8	scraper	/skɹəʊpi/
	3-syllable	
9	gorilla	/gæɹɒlu/
10	acrobat	/ɪkɹɪbʊt/
11	anchovy	/ʊntʃɛɪvɑ/
12	grasshopper	/gɹushɛpɪ/
	4-syllable	
13	chrysanthemum	/kɹʌzɒnθɪmɛm/
14	librarian	/laʊbɹəʊɹɪaʊn/
15	ballerina	/bʌlɹɑnɪ/
16	satisfaction	/sɒtæsfɛkʃn/
	5-syllable	
17	encyclopeadia	/ʊnsɪəklaɪpɑdʒɪ/
18	multiplication	/mɒltɪplɪkaʊʃn/
19	electricity	/ɒlɪktɹæsʊta/
20	refrigerator	/ɹɒfrædʒɒɹəʊtɪ/

Articulatory naming task:
List of stimuli

Picture stimuli

1 hippopotamus
2 screwdriver
3 acorn
4 strawberry
5 microscope
6 ballerina
7 elephant
8 helicopter
9 umbrella
10 giraffe
11 seahorse
12 puppet
13 hammock
14 stethoscope
15 binoculars
16 pyramid
17 octopus
18 rhinoceros
19 saddle
20 unicorn

From Snowling, M., Van Wagtendonk, B. & Stafford, C. (1988). Object naming deficits in developmental dyslexia. *Journal of Research in Reading,* 11, 67-85.

Auditory discrimination: same/different task: List of stimuli

Nonwords

	Feature	Sequence
1	/blɛɪs/ /blɛɪt/	/blɛɪst/ /blɛɪts/
2	/dɪt/ /dɪs/	/dɪts/ /dɪst/
3	/zɛt/ /zɛt/	/zɛst/ /zɛst/
4	/pəʊt/ /pəʊt/	/pəʊts/ /pəʊts/
5	/jɛɪs/ /jɛɪt/	/jɛɪts/ /jɛɪst/

Words

	Feature	Sequence
6	race rate	rates raced
7	met met	messed messed
8	goat goat	goats goats
9	plate place	placed plates
10	miss mitt	mitts missed

Adapted from Bridgeman, E. & Snowling, M. (1988). The perception of phoneme sequence: a comparison of dyspraxic and normal children. *British Journal of Disorders of Communication* 23, 3: 245-252.

Auditory discrimination: ABX task: List of stimuli

RW from which derived		*A*	*B*	*X*	*Manipulation*
1-syllable					
1	snake	/naɪk/	/snaɪk/	/naɪk/	C
*2	van	/vɪn/	/zɪn/	/vɪn/	Pl
3	plate	/pəʊt/	/pləʊt/	/pləʊt/	Cl
*4	fish	/vɛʃ/	/fɛʃ/	/fɛʃ/	V
*5	train	/tɔɪn/	/trɔɪn/	/tɔɪn/	Cl
6	brush	/bɹɪs/	/bɹɪʃ/	/bɹɪʃ/	Pl
7	sponge	/spændʒ/	/spændz/	/spændz/	Pl
*8	glove	/glɛb/	/glɛv/	/glɛb/	M
2-syllable					
9	guitar	/tɛˈgɔ/	/gɛˈtɔ/	/gɛˈtɔ/	Meta
10	sausage	/ˈsɛdʒəs/	/ˈsɛsədʒ/	/ˈsɛdʒəs/	Meta
11	slipper	/ˈslɔpə/	/ˈlɔpə/	/ˈslɔpə/	Cl
*12	yellow	/ˈlæjɔɪ/	/ˈjælɔɪ/	/ˈlæjɔɪ/	Meta
*13	tractor	/ˈdɹɛktɪ/	/ˈtɹɛktɪ/	/ˈtɹɛktɪ/	V
14	jelly	/ˈdzʌlə/	/ˈdʒʌlə/	/ˈdzʌlə/	Pl
*15	spider	/ˈspɛɪdɪ/	/ˈstɛɪbɪ/	/ˈstɛɪbɪ/	Meta
*16	flower	/ˈfluwɪ/	/ˈsluwɪ/	/ˈsluwɪ/	Pl
3/4-syllable					
17	elephant	/ˈæfɪlɒnt/	/ˈælɪfɒnt/	/ˈæfɪlɒnt/	Meta
18	umbrella	/æmˈbɹælɪ/	/æmˈblæɹɪ/	/æmˈblæɹɪ/	Meta
19	butterfly	/ˈbætəfləʊ/	/ˈbætəfəʊ/	/ˈbætəfləʊ/	Cl
*20	parachute	/ˈpɛɹəsit/	/ˈpɛɹəʃit/	/ˈpɛɹəʃit/	P
*21	aeroplane	/ˈɒɹəprəʊn/	/ˈɒɹəpləʊn/	/ˈɒɹəprəʊn/	Pl
*22	caterpillar	/ˈkɪtəpælə/	/ˈkɪpətælə/	/ˈkɪpətælə/	Meta
23	pyjamas	/pɪˈdʒɔmɪz/	/pɪˈdʒɔbɪz/	/pɪˈdʒɔmɪz/	M
*24	spaghetti	/spʌˈgɪtə/	/gʌsˈpɪtə/	/spʌˈgɪtə/	Meta

* = items used at T1 (n=12)
Codes:

V	Voicing	Pl	Place of articulation
Cl	Cluster reduction	M	Manner of articulation
Meta	Metathetic change		

From list devised by Vance, Stackhouse & Wells (1995), UCL

Auditory discrimination: picture task (original version): List of stimuli

	Picture	*Nonword Stimulus*	*Type of manipulation*
1-syllable			
1	snake	/nεik/	Cl
2	van	/zæn/	Pl
3	plate	/pεɪt/	Cl
4	fish	/vɪʃ/	V
5	train	/tεɪn/	Cl
6	brush	/bɹʌs/	Pl
7	sponge	/spʌndz/	Pl
8	glove	/glʌb/	Ma
2-syllable			
9	guitar	/tɪˈgɑ/	Meta
10	sausage	/ˈsɒdʒɪs/	Meta
11	slipper	/ˈlɪpə/	Cl
12	yellow	/ˈlεjəʊ/	Meta
13	tractor	/ˈdɹæktə/	V
14	jelly	/ˈdzεlɪ/	Pl
15	spider	/ˈstaɪpə/	Meta
16	flower	/ˈslaʊwə/	Pl
3/4-syllable			
17	elephant	/ˈεfɪlənt/	Meta
18	umbrella	/ˈʌmlεɹə/	Meta
19	butterfly	/ˈbʌtəfaɪ/	Cl
20	parachute	/ˈpæɹəsut/	Pl
21	aeroplane	/ˈεɹəpɹεɪn/	Pl
22	caterpillar	/ˈkæpətɪlə/	Meta
23	pyjamas	/pəˈdʒɑbəz/	M
24	spaghetti	/gəˈspεtɪ/	Meta

Codes:

V	Voicing	Pl	Place of articulation
Cl	Cluster reduction	M	Manner of articulation
Meta	Metathetic change		

From list devised by Vance, Stackhouse & Wells (1995), UCL

Auditory discrimination: picture task (Extension task): List of stimuli

	Picture	*Nonword Stimulus*
	3-syllable	
1	hospital	/ˈhɒspɪpəl/
2	elephant	/ˈɛfɪlənt/
3	crocodile	/ˈkɹɒdəkaɪl/
4	microphone	/ˈmaɪkɹəkəʊn/
5	octopus	/ˈɒˀpətəs/
	4-syllable	
6	escalator	/ˈɛskəleɪkə/
7	binoculars	/bɪˈlɒkjunəz/
8	helicopter	/ˈhɛlɪkɒpkə/
9	television	/tɛvɪˈlɪʒən/
10	caterpillar	/ˈkatətɪlə/

Adapted from Constable, A., Stackhouse, J. & Wells, B. (1997). Developmental word-finding difficulties and phonological processing: The case of the missing handcuffs. *Applied Psycholinguistics*, 18, 507-536.

Accent lexical Decision task: List of stimuli

Word and nonword stimuli presented for the London and Glaswegian accent conditions

LIST A

Word	London	Glas	Nonword	London	Glas
Bird	[bɜ̟ːd̥]	[bʌɾ̥d̥]	*dird*	[dɜ̟ːd̥]	[dʌɾ̥d̥]
coat	[kʰʌʉ̞ʔ]	[kʰo̟ʔ]	*toat*	[tʰʌʉ̞ʔ]	[tʰo̞ʔ]
fork	[fɔ̞ʊʔk]	[fɔɹʔkʰ]	*sork*	[sɔ̞ʊʔk]	[sɔɹʔkʰ]
sock	[sɒʔk]	[sɔʔkʰ]	*tock*	[tʰɒʔk]	[tʰɔʔkʰ]
mouse	[mæ̞ʊs]	[mʌ̟ʏs]	*bouse*	[bæ̞ʊs]	[bʌ̟ʏs]
hand	[hæ̃ːnd̥]	[hand̥]	*fand*	[fæ̃ːnd̥]	[fand̥]
bite	[bɑɪʔ]	[bʌɪʔ]	*pite*	[pʰɑɪʔ]	[pʰʌɪʔ]
soap	[sʌɣ̟ʔp̚]	[soʔpʰ]	*foap*	[fʌɣ̟ʔp̚]	[foʔpʰ]
food	[fʉd̥]	[fʏd̥]	*vood*	[vʉd̥]	[vʏd̥]
wave	[wɛ̞ɪy̥]	[weːy̥]	*lave*	[lɛ̞ɪy̥]	[leːy̥]
nurse	[nɜ̟ːs]	[nʌɹ̥s]	*surse*	[sɜ̟ːs]	[sʌɹ̥s]
bath	[b̥ɑːf]	[b̥aːθ]	*gath*	[g̊ɑːf]	[gaːθ]

LIST B

Word	London	Glas	Nonword	London	Glas
girl	[gɛːʊ]	[gɪɾl]	*dirl*	[dɛːʊ]	[dɪɾl]
boat	[bʌʉ̞ʔ]	[bo̞ʔ]	*doat*	[dʌʉ̞ʔ]	[do̞ʔ]
walk	[wɔ̞ʊʔkʰ]	[wɔʔkʰ]	*ralk*	[ɹɔ̞ʊʔkʰ]	[ɾɔʔkʰ]
box	[bɒʔks]	[bɔʔks]	*mox*	[mɒʔks]	[mɔʔks]
mouth	[mæʊf]	[mʌ̟ʏθ]	*bouth*	[bæʊf]	[bʌ̟ʏθ]
sand	[sæ̃ːnd̥]	[saːnd̥]	*shand*	[ʃæ̃ːnd̥]	[ʃaːnd̥]
kite	[kʰɑɪʔ]	[kʰʌ̟iʔ]	*gite*	[gɑɪʔ]	[gʌ̟iʔ]
rope	[ɹʌɣ̟ʔp̚]	[ɹ̠oʔpʰ]	*wope*	[wʌɣ̟ʔp̚]	[woʔpʰ]
boot	[bʉːʔt̚]	[bʏʔ]	*poot*	[pʰʉːʔ]	[pʰʏʔ]
game	[gɛ̞ɪm]	[gem]	*bame*	[bɛ̞ɪm]	[bem]
church	[tʃʲɜ̟ːʔtʃʲ]	[tʃʌɹʔtʃ]	*turch*	[tʰɜ̟ːʔtʃʲ]	[tʰʌɹʔtʃ]
path	[pʰɑːf]	[pʰaːθ]	*kath*	[kʰɑːf]	[kʰaːθ]

From Nathan, L. & Wells, B. (in press). Can children with speech difficulties process an unfamilar accent? *Applied Psycholinguistics.*

Letterhead

STRICTLY CONFIDENTIAL

DEVELOPMENTAL QUESTIONNAIRE

I. BIRTH AND GENERAL HEALTH DETAILS

1. Child's name________________________________

2. Child's date of birth Day_____ Month________ Year________

3. Please list your other children (if any) by age and date of birth:

   Children Age Date of birth

4. Was your child born prematurely? YES/NO

5. Were there any complications associated with the birth? YES/NO

6. Did your child have any feeding difficulties? YES/NO

7. Does your child suffer from any of the following:

Allergies	YES/NO
Fits	YES/NO
Asthma	YES/NO
Frequent coughs and colds	YES/NO
Ear infections	YES/NO
Catarrh	YES/NO

II. DEVELOPMENT SINCE BIRTH

Physical development

8. Approximately how old was your child when he/she began to walk?

9. Have you been worried about your child's physical development?

YES/NO

IF YES

9a. What caused this concern? ______________________________

____

9b. Was any help/treatment sought for this? YES/NO

IF YES

9c. Was help/treatment given? YES/NO

9d. Are there still problems? YES/NO

Hearing

10. Have you been worried about your child's hearing? YES/NO

IF YES

10a. What caused this concern? ______________________________

____

10b. Was any help/treatment sought for this? YES/NO

IF YES

10c. Was help/treatment given? YES/NO

10d. Are there still problems? YES/NO

Speech and Language

11. Approximately how old was your child when he/she began to talk?

12. Have you been worried about your child's speech or language development? YES/NO

IF YES

12a What caused this concern? ______________________

____

____

12b. Was any help/treatment sought for this? YES/NO

IF YES

12c. Was help/treatment given? YES/NO

12d. Are there still problems? YES/NO

Vision

13. Have you been worried about your child's vision? YES/NO

IF YES

13a. What caused this concern? ______________________

____

13b. Was any help sought for this? YES/NO

IF YES

13c. Was help/treatment given? YES/NO

13d. Are there still problems? YES/NO

Reading and Spelling

14. Have you been worried about your child's reading? YES/NO

IF YES

14a. What caused this concern? ____________________________

____

____

14b. Was any help sought for this? YES/NO

14c. Was help given? YES/NO

14d. Are there still problems? YES/NO

15. Have you been worried about your child's spelling? YES/NO

IF YES

15a. What caused this concern? ____________________________

____

____

15b. Was any help sought for this? YES/NO

15c. Was help given? YES/NO

15d. Are there still problems? YES/NO

III FINAL SECTION

Please use this space if there is any more information you would like us to have.

Name: ______________________________

Signed: _____________________________

Date: ______________

THANK YOU VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE

PLEASE RETURN TO LIZ NATHAN AT THE ADDRESS ABOVE

Letterhead

STRICTLY CONFIDENTIAL

PARENTAL QUESTIONNAIRE (MOTHER)

TO BE COMPLETED BY THE MOTHER OF THE CHILD IN THE STUDY

I. GENERAL DETAILS

1. Name____

2. Child's name__________________________________

II. EDUCATIONAL DETAILS

3. Number of CSE, GCSE or GCE 'O' level passes______

4. Number of GCE 'A' level passes__________________

5. Qualifications gained in further or higher education_____

   ____

6. Any other qualifications__________________________

   ____

III. OCCUPATIONAL DETAILS

Please give your present occupation. (If you are unemployed, or are engaged in full-time child care, please give your previous occupation).

7. Post/title______________________________________

IV. SELF AND FAMILY

8. Do you or any of the following members of your family have a history of reading/spelling difficulties:

You	YES/NO
Your parents	YES/NO
Your grandparents	YES/NO
Your brothers/sisters	YES/NO

9. Do you or any of the following members of your family have a history of speech difficulties:

You	YES/NO
Your parents	YES/NO
Your grandparents	YES/NO
Your brothers/sisters	YES/NO

10. Have you ever attended a speech therapy clinic? YES/NO

11. Have you ever suffered from a hearing loss? YES/NO

V FINAL SECTION

Please use this space if there is any more information you would like us to have.

Name: Signed:
Date:

THANK YOU VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE

PLEASE RETURN TO LIZ NATHAN AT THE ADDRESS ABOVE

Letterhead

STRICTLY CONFIDENTIAL

PARENTAL QUESTIONNAIRE (FATHER)

TO BE COMPLETED BY THE FATHER OF THE CHILD IN THE STUDY

I. GENERAL DETAILS

1. Name____

2. Child's name_________________________________

II. EDUCATIONAL DETAILS

3. Number of CSE, GCSE or GCE 'O' level passes______

4. Number of GCE 'A' level passes___________________

5. Qualifications gained in further or higher education_____

   ____

6. Any other qualifications___________________________

   ____

III. OCCUPATIONAL DETAILS

Please give your present occupation. (If you are unemployed, or are engaged in full-time child care, please give your previous occupation).

7. Post/title_______________________________________

IV. SELF AND FAMILY

8. Do you or any of the following members of your family have a history of reading/spelling difficulties:

You	YES/NO
Your parents	YES/NO
Your grandparents	YES/NO
Your brothers/sisters	YES/NO

9. Do you or any of the following members of your family have a history of speech difficulties:

You	YES/NO
Your parents	YES/NO
Your grandparents	YES/NO
Your brothers/sisters	YES/NO

10. Have you ever attended a speech therapy clinic? YES/NO

11. Have you ever suffered from a hearing loss? YES/NO

V FINAL SECTION

Please use this space if there is any more information you would like us to have.

Name: Signed:
Date:

THANK YOU VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE

Please return to Liz Nathan at the address above

Letterhead

NTRHA Research Project

Therapy Record Form

Please return to Liz Nathan at the above address

Please complete/circle as appropriate

*Dates: from 1st referral to SLT up until ___________199
Name DOB
Address
Tel

1. *Date of referral to SLT Service (*) :*

2. *Date of initial appointment:*

3. *No. of sessions offered during the above period (*):*

4. *No. of sessions attended during the above period (*):*

5. *No. of individual sessions: (*)*

6. *No. of group sessions: (*)*

7. *Approx.imate length of session:*

8. *Type of therapy:* phonological (eg. mimimal pairs, Metaphon)

oral motor skills articulatory therapy phonological awareness

expressive language receptive language play skills listening skills

social skills parent workshop parent-child interaction

other (please specify):

9. *Therapy setting:* clinic school language unit

other (please specify)

10. How often did liaison take place between SLT and nursery/school:

once a year once a term occasional none to date _

other (please specify) ____________

11. What was the management of the child during the above period (*):

regular for therapy on review on waiting list

planned discharge discharged

other (please specify) _______

12. Is the child: not statemented (ie. no plans to begin process)

statemented at stage 1 / 2 / 3 / 4 of statement

13. Any other changes/observations of note (eg. failed hearing test, change of school, hospitalisation):

14. Please specify other agencies involved:

ENT OT Physio Ed. Psychologist

Social Worker Child Guidance

Other (please specify) ___________

15. Other comments:

Signed:
Name of therapist:
Base:
Date

Letterhead
NTRHA Research Project

Therapy Record Form

Please return to Liz Nathan at the above address

Please complete/circle as appropriate

*Dates: from ________________199 until ___________199
Name DOB
Address
Tel

1. *No. of sessions offered during the above period (*):*

2. *No. of sessions attended during the above period (*):*

3. *No. of individual sessions: (*)*

4. *No. of group sessions: (*)*

5. *Approximate length of session:*

6. *Type of therapy: (please indicate percentage of time spent on activity during the above period):*

phonological (eg. minimal pairs, Metaphon) ____%

oral motor skills ____% articulatory therapy ____% phonological awareness ____%

expressive language ____% receptive language ____% play skills ____%

listening skills ____% social skills ____%

parent workshop ____% parent-child interaction ____%

other (please specify):

7. *Therapy setting:* clinic school language unit

other (please specify)

8. *How often did liaison take place between SLT and nursery/school:*

once a year once a term occasional none to date

other (please specify)

•

9. *What was the management of the child during the above period (*):*

regular for therapy on review on waiting list

planned discharge discharged (please state reason)

other (please specify)

10. *Is the child:* not statemented (ie. no plans to begin process)

statemented at stage 1 / 2 / 3 / 4 of statement

11. *Any other changes/observations of note during above period* (eg. failed hearing test, change of school, hospitalisation):

12. *Please specify other agencies involved:*

ENT OT Physio Ed. Psychologist

Social Worker Child Guidance

Other (please specify)

13. *Other comments:*

Signed:
Name of therapist:
Base:
Date: